SCIENTIFIC AMERICAN SUPPLEMENT, No. 984

Copyright by Munn & Co., 1894.

Scientific American Supplement, Vol. XXXVIII. No. 984
Scientific American, established 1845.

NEW YORK, NOVEMBER 10, 1894.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

LI HUNG CHANG.

LI HUNG CHANG is the great man of China. No career of a statesman has been more honored than that of Li Hung Chang, but it seems finished, and the grave events of the last few months have brought disgrace upon the old statesman. In the war between China and Japan all eyes turned to Li Hung Chang. At this time, when he should be all-powerful, he is disgraced. The biography of Li Hung Chang has been written a thousand times, there is not a dictionary, geographical, historical or biographical which does not recount at length the brilliant history of this man, so picturesque, so unusual in the annals of the history of China. Originally from the Province of Anhui, he graduated in 1847. In 1853 he fought the Taipings. From this time on fortune smiled on Li. His name became illustrious in this memorable conflict, he was proclaimed as the saviour of his country and obtained the famous yellow jacket. In 1854 he was named Taotai in the Province of Tonkin. In 1862 he was appointed governor of Kiangsu, superintendent of the treaty ports of the south and governor-general of Hou-Kouang in 1867. Finally in 1875 he became premier, with the title of "Po" or noble of the third order. The presidency of the council of war and the direction of the navy devolved upon him. He is also Count Shinu-Ki. Such is in brief the life of the man who is called, not without reason, the "Bismarck of China."

Li is tall and spare and his forehead is very fine, the eyes of the old man are still bright and his keenness of sight is remarkable in a man seventy-seven years old. A drooping moustache and a small beard give him a military aspect. There is, however, nothing in this physiognomy, which appears so benevolent, to suggest the terrible conqueror of the Taipings. Our second engraving will give an idea of the port of Che-Foo, Corea, one of the scenes of the hostilities now raging between Japan and China. For our illustrations we are indebted to L'Illustration.

LI HUNG CHANG, WITH HIS SON AND GRANDSONS.

ABORIGINES OF THE WEST INDIES.*

By FREDERICK A. OBER.

A NEGLECTED field of scientific research, yet lying adjacent to and between the two great continents of America, is that comprising the vast collection of islands known as the West Indies. Although containing the first islands discovered by Columbus, and including the seas first traversed by Spanish ships in the New World, it was many years before the actual condition and population of those islands was made known to the civilized world. Even now, less, perhaps, is known respecting them than of many portions of lands considered unexplored. The West Indies are divided, as is well known, into the Greater and the Lesser Antilles, the former comprising the islands of Cuba, Jamaica, Santo Domingo or Haiti and Puerto Rico, to which we may add the Bahamas; the latter, that crescent-shaped archipelago called the Caribbean Chain, connecting the larger islands with the continent of South

* Abstract in the Boston Commonwealth, from an interesting paper presented by Mr. Ober before the American Antiquarian Society at the last semi-annual meeting and to appear in the forthcoming volume of the proceedings.

THE PORT OF CHE-FOO, COREA.

America. These, again, are locally divided into Windward and Leeward, with reference to their situation respecting the prevailing trade winds.

All these islands were inhabited, at the time of their discovery, by people called by Columbus "Indians," and possessed of characteristics which distinguished them from any others at that time known to Europeans.

We are told by the historian that people seen on the islands where Columbus first landed were of a tawny or copper complexion, that they went about naked and possessed but a few of the articles considered necessary to civilized man. They possessed no article of iron or bronze, their weapons being lances tipped with fishbones or stone, and bows and arrows. Their huts were of the simplest materials, made of palm leaves, such being amply sufficient in the delightful climate of those tropical islands. The fact that remains of these Indians have been found in caves and under overhanging rocks does not warrant us in the inference that they were in any sense Troglodytes; since the Bahamas abound in such caverns, and to them these people naturally turned for refuge, when subsequently pursued by the Spaniards, and for shelter. They were gentle and peace-loving, as we have testimony from Columbus himself; shapely and athletic; having no wars, except with occasional invaders from the south. All their traditions: of origin, of the existence of gold (a few ornaments in which metal they wore), of invasion, of a country greater than their own, pointed to the south. They told Columbus that he could find gold in great quantities in the south as well as a great chief, and numerous other peoples. At the time of their discovery, these Bahamas possessed tame parrots (which no longer exist on Watling's Island, but are found on Acklin, about a hundred miles away), and these seem to have been the only domesticated pets from the scant animal life about them. The most noticeable article they owned was the canoe (canoa), the largest of which would hold more than forty men, which they propelled by means of paddles and baled out with calabashes.

At Guanahani, then, the aborigines were found possessed of parrots, crude implements of bone and stone, canoes, huts of palm leaves, a few articles of gold, and little, if anything, else, except cotton. Later on at the third island visited, called by Columbus Fernandina, now known as Long Island, the Europeans added to this brief list hammocks, tobacco and cassava bread. "Their beds and covering," said Columbus, "looked like cotton nets, which they called hamacas;" and, "the Indian captured by us in the channel between Santa Maria and Fernandina had some dry leaves, highly prized, no doubt, among them, for those of San Salvador offered some to me as a present." This was tobacco, which was afterward found in quantities in Cuba, where the natives were seen smoking it.

The Indians of the Bahamas were soon exterminated, although Columbus did not revisit the scene of his discoveries; and as early as 1508, when the cruelties of the Spaniards had nearly depopulated Haiti, the natives were carried hence to labor in the mines. Under their cruel enslavers the Lucayans sank rapidly; it is on record that some forty thousand were transported, never to return, and the islands once teeming with happy life were finally left desolate. I cannot state exactly the period of their depopulation; in the year 1512, when Ponce de Leon sailed through the Bahamas in search of the fountain of youth, he found some of the islands inhabited, for he was told of the famous fountain by natives of the northern islands; but doubtless the southern ones were already deprived of all their inhabitants, even that early. Respecting that search for the mythical fountain of youth, I may say that my investigations were made in the island of Puerto Rico, whence De Leon sailed on his quest, and that there I discovered his remains yet are treasured, as well as many relics of his time. He cruised the archipelago just twenty years after Columbus, and also in 1521, the year of his death, when he was wounded on the coast of Florida, taken to Cuba, where he died, and thence his remains brought back to Puerto Rico.

Doubtless the natives were entirely exterminated before the end of the sixteenth century, as when the English settled the Bahamas, about 1629, not one remained. The historians Herrera and Martyr give all details of the means by which their extermination was hastened, and to their pages I would refer the curious student. I find reference to them in a work published in 1666, as follows: "That poor nation, the Lucayos, hath been utterly destroyed by the Spaniards, or carryed away and made slaves to work in the mines, and there are not, in any of the islands known under that name, any of the natural inhabitants; but only some few English, who were transported thither out of the Island of Bermudez."

We may confidently assume that it is full three hundred years since the Bahamas knew the presence of any of its aboriginal inhabitants. Let us now examine the evidence of their former occupancy, as given in the few relics recovered at various times. Of the people themselves, the Lucayans, or Ceboyans as they have been termed, few remains have been found, and these few mainly in caves. Several skeletons have been recovered, but I cannot learn that any in its entirety has been deposited in any museum. In the public library of Nassau, New Providence, are two crania of the aboriginal Ceboyans, and I brought one other from Watling's Island, which was exhibited at the Chicago Exposition and afterward given to the Columbian Museum. Of these crania, Prof. W. K. Brooks, of the Johns Hopkins University, says: "The skulls are extremely broad in proportion to their length, and are among the most brachycephalic of all human skulls, the greatest breadth being more than nine-tenths of their greatest length. The brain was large, the capacity of the cranium about equal to that of an average Caucasian skull. The Ceboyans flattened their heads artificially in infancy, so that the vertical part of forehead is completely obliterated in all adult skulls, and the head slopes backward immediately above the eyes."

I myself found bones and many fragments in the caves I explored on Watling's and Cat Islands; but all the caves of the Bahamas have long since been thoroughly investigated, during the search for cave earth or bat guano. As these investigations were not conducted in the interests of science, such bones and crania as were found were not taken into account, and in most instances were lost to the museums. The dry earth of the caves was the best medium possible for preserving objects deposited therein, and not only bones, but various articles of domestic use among the Lucayans, have been discovered. At the Jamaica Exposition, of 1891, were exhibited many such articles, and among them a few that are almost entirely unique; such as a carved seat lignum vitæ, a stone ax inserted in a handle of wood, and another with head and haft of one stone. The seats of wood are described by the early historians as seats used by the chiefs, made in the form of beasts and reptiles and carved out of one piece of wood. One such specimen is now preserved in the Smithsonian Institution, at Washington, and another is in the public library of Grand Turk's Island, Bahamas.

In addition to these important relics of native workmanship, which were found in caves in the Caicos and Grand Turk, the usual "celts" are discovered, though rarely, throughout the entire chain. As the Bahamas include some two thousand islands and rocks, and the character of the calcareous rock is such that caves and pot holes abound everywhere, it is possible that many articles may yet be found, that have escaped the eyes of the guano hunter. Throughout the islands, the smaller celts are known as "thunderbolts," and are treasured by the present natives as of celestial origin and possessing supernatural virtues. They declare that they fall from the clouds in time of storm, and I have met with individuals who told me they themselves saw some descend. One old darky declared to me that he saw one strike a tree, in the midst of a flash of lightning, and afterward recovered the identical stone. This name is of universal application, and in the Spanish islands the stones are called "piedras de rayo"—thunderbolts—as well as in the English and French islands.

A strange fact may be noticed with reference to these celts, and that is that all, or nearly all, are made from stone not to be found within the area of the Bahaman chain. They are most assuredly of foreign origin, and were probably brought here from the southern islands, as Puerto Rico or San Domingo; another evidence of the truth of the statement by the early historians, that the Indians performed long voyages in their canoes. They are of fine, dark stone, compact in grain, and polished, being excellent specimens of the neolithic age. One small celt, which I obtained at Long Island, is of perfect shape and exquisitely rounded, and resembles another which I got in the interior of the island of Santo Domingo. All that I have seen are of the dark green stone, and I have not found any of any other kind. There is not any evidence of implements having been made from conch shell, which is so abundant and from which the natives of Barbadoes and the southern islands made their chisels and other articles. One remarkable specimen, which was discovered in a field, by a negro, in 1892, and brought to Nassau, during my stay there, is ten and one-half inches long, three and one-half inches broad, and has carved upon it a face, as in a moon, with oblique, oriental eyes. This also is of dark green stone, probably jade or serpentine, and is the only one of the kind I have seen.

I should not omit to mention a canoe which was found in a cave on Watling's Island, but of which since its discovery I cannot find any trace. In an inquiry into the origin of these relics, we cannot find that any are absolutely unique, or autochthonic, except, possibly, the stone ax in one piece, and the stools, or seats. But even these latter are found in Haiti and Santo Domingo, on the north coast, and from this fact one might imply a southern origin for all these articles, or a similar people inhabiting there. Herrera speaks of the first ones discovered in Cuba, on the first visit of Columbus, as follows: "Seats made of a solid piece of wood in the shape of a beast with very short legs and the tail held up, the head before with eyes and ears of gold." These were used only by the chiefs, the common people squatting on the ground. The two specimens in the Smithsonian are from Turk's and Caicos Islands; but there is a stone specimen of this type also from Puerto Rico; and it is thought that the form may have been suggested by the hammock, as the stools have a similar curve or sweep.

The Indians of the Bahamas doubtless depended chiefly for subsistence upon the products of the sea; fish, which are so abundant around the shores of their islands, and especially upon conches, found in countless numbers on the reefs and in the shallow lagoons. Of animal food they probably partook but sparingly, there being no large quadrupeds on the islands; and birds must have been hard to capture. Sea birds and their eggs, in the season, gave them supplies, probably, and they ate the flesh and eggs of the iguana, which is still common, turtles also, with their eggs; the seas abound in turtle. They cultivated but little, the soil of the Bahamas being thin and in many of the islands contained in more or less extensive pockets in the calcareous rock; but they had maize and yucca, perhaps fruits like the pineapple and others native to the soil. Nature was kind to these children of nature, and they led a careless existence, depending chiefly upon the bounties of the sea.

Following still in the trail of Columbus, and taking the island next discovered by him after he left the Bahamas we arrive at Cuba, which he discovered the last of October, 1492. He landed on the north coast, probably at or near the present port of Jibara, and there saw the Indians of Cuba. They were more advanced than the inhabitants of the Bahamas, but on the same lines of progression, probably owing to the superiority of their island over the others in point of size and fertility. That is, they had better and more numerous houses hidden in shady groves, more extensive fields of maize and manioc, and more numerous articles of domestic use.

Coasting the northern shore of Cuba—which, by the way, still retains its aboriginal name—Columbus discovered villages and people similar to the Lucayans, and sent an embassy into the interior, to treat with the cacique, whom he is supposed to have assumed was the Grand Khan. When the embassy returned, the navigators learned their mistake; but they had added several articles to previous finds, and found the inhabitants possessed of a slightly higher type of civilization. They found the Indians smoking tobacco, in rolls; their huts hung with hammocks, and using the carved seats to which allusion has been made. They had also greater stores of cotton, in yarn and woven into nets, a greater variety of fruits, and also of animals from which to derive subsistence. In addition to the larger number and more numerous species of birds, there were also several mammals, non-existent in the Bahamas. Little gold was found in the keeping of the natives, but they told of a region of gold to the southward, which they called Bohio, since proved to have been the island of Haiti.

Cuba was left for twenty years after its discovery in comparative possession of the natives, when the settlements were then attempted which eventually led to their extinction. No date is given as to the final extinction of the Indians of Cuba, but it was not long after the arrival of Valasquez and his crew and the sailing of Cortez for Mexico; for the barbarities of the Bahamas and Haiti were re-enacted on this island until the natives killed themselves by scores, in despair and to escape the Spaniards.

Affecting stories are narrated of the conquest of this island; but to no avail did the natives struggle for mere subsistence and a life of freedom. The largest settlements seem to have been in the eastern end of Cuba; at least that is where the greatest number of relics have been found. In the Real Academia, of Havana, are to be seen a few of these remains of the primitive Cubans, in the shape of stone axes and other implements, and particular attention is called to some crania, embedded in lime rock, discovered in caves near Cape Maisi, the extreme eastern end of Cuba, by a gentleman of Havana. These skulls, of which several were obtained, are brachycephalic, having a cephalic index of above 90, one of them showing 93·75, another 90, and all with more or less pronounced frontal depressions, artificially produced. They are, of course, of great antiquity, some of them having been found embedded entirely in the calcareous rock of the caverns and covered with thick deposits of bat guano. As to their antiquity, I will not hazard conjecture. Fragments of pottery and some implements were also obtained, such as a clay figure, an earthen jar which contained Indian bones, an ax or hatchet of serpentine, beautifully polished, and several minor articles of the class called "piedras de rayo," or thunderbolts—in Cuba as elsewhere.

But enough has been shown to prove that the natives of Cuba were allied to those of the Bahamas, and had surpassed them, only in degree, on the same lines of development. As will be alluded to farther on, the natives of all the Greater Antilles, and including the Bahamas, were of the same stock, as shown by their racial characteristics and linguistic affinities.

Jamaica, though it did not immediately follow in the series of Spanish discoveries, yet was brought into prominence soon after the first settlement was accomplished in Haiti. Discovered by Columbus in May, 1494, it was on the north coast of this island that he was wrecked, on his last voyage, in 1503. It was in February, 1504, that Columbus imposed upon the credulous natives in that famous prediction of the lunar eclipse, by which he compelled them to supply him with provisions for months, without which he would have perished, as he was a twelvemonth on the island without means of escape.

Jamaica was a very populous island, the hills and valleys swarming with Indians; but they likewise perished under the exactions of the Spaniards. The first Spanish settlement was commenced in 1509, and shortly after that the natives began to decrease rapidly. History is silent as to the date of their final disappearance, but at the time of the first English invasion, in 1596, there was none left. Xaymaca, the Land of Springs, with its fertile soil and beautiful pimento groves, was soon left desolate, so far as the aboriginal inhabitants were concerned. Their number was estimated at above 60,000; Sir Hans Sloan, a historian of Jamaica, writing about 1670, says: "In some small time, the Indian inhabitants to the number of 60,000 were all destroyed by the severities of the Spaniards; I have seen in the woods many of their bones, in caves, which some people think were of such as had voluntarily inclosed or immured themselves, in order to be starved to death." He also mentions a man who saw about 1677, "a cave in which lay human bones, all in order; also pots and urns, wherein were bones of men and children. These pots were oval and large, of a reddish dirty color; on the upper part of the rim or ledge there stood out an ear, on which were made some lines. The negroes had removed most of these pots to boil their meat in."

Gomara says that the Spaniards made slaves of the Indians for various trivial reasons; as, because they ate insects and maggots (probably locusts and larvæ of the palm beetle); that they intoxicated themselves with wine of maize and other native plants, smoked tobacco, and plucked their beards out by the roots. But, on the other hand, the natives, who were notoriously abstemious, were shocked and disgusted at the enormous appetites of the Spaniards, and at their revels and licentiousness. By consuming the scant crops of the Indians, who only provided themselves from year to year, and by debauching their wives and daughters, famine and disease were soon familiar specters among these people, who had hitherto lived in health and happiness. Speaking of the Indians in Jamaica, two hundred years ago, Sir Hans Sloan says: "They are not natives of the island, they being all destroyed by the Spaniards, but are usually brought by surprise from the Mosquitos or from Florida, or such as were slaves to the Spaniards and taken from them by the English. They are very good hunters and fishers, but are naught at working in the field or slavish work, and if checkt or drubbed are good for nothing, therefore are very gently treated and well fed." This naive confession as to the treatment of the slaves and Indians, in relation to their white masters, should have given the first named a hint; indeed, the escaped negroes, or maroons, did profit by it, and held themselves aloof in the woods and mountains.

The Indians of Jamaica impressed Columbus most favorably, if we may believe the accounts he left of his discovery and first meeting with them. They possessed great canoes capable of carrying some eighty or a hundred warriors each; the first cacique to greet him came out in a beautiful canoe, in the prow of which stood the standard bearer, "clad in a mantle of

variegated feathers, with a tuft of gay plumes on his head, and bearing in his hand a fluttering white banner. Two Indians, with caps or helmets of feathers of similar shape and color, and their faces painted, beat upon tabors; two others held trumpets of fine black wood, ingeniously carved." The two daughters of the cacique, "beautiful in form and countenance," were naked, but unabashed, and of modest demeanor. Around the head of the chief was a band of stones of various colors, two plates of gold were suspended from his ears by rings of very small green stones, and from a necklace of white beads was hung another plate of 'guanin' or inferior gold, in the shape of a fleur-de-lis, while a girdle of stones was worn around his waist. His wife had on an apron of cotton, with similar adornments to the chief, and bands around her arms, while the girls wore no ornament, save their native modesty and a girdle of green stones.

How soon these peaceful and happy people were made to suffer want and experience all the horrors of slavery, eventually to be exterminated, we have already seen. Of gold and precious stones, the Spaniards obtained little in Jamaica, the few articles found in possession of the natives having, probably, been obtained from Haiti, or the coast of Veragua; but some of their implements of warfare and domestic life have been recovered by later investigators; differing in no important particulars from those of Cuba and Haiti.

One of the few deposits of ancient pottery and implements has been described by Lady Edith Blake, the talented consort of the present governor of Jamaica, Sir Henry Blake. About six miles to the east of Kingston, she says, on ground sloping gently down to the Liguanea Plain, is the site of an ancient Indian settlement. "To the east the field is abruptly terminated by a sudden dip and bank of some sixteen or eighteen feet in height. On digging into this bank, layer upon layer of shells are found mingled with pottery more or less broken, a few small bones, and now and then a stone hatchet. Here and there, some of the shells show traces of fire. The pottery is of different degrees of thickness, and we found a few bits that bore traces of ornamentation. The clay of which it was made is coarse and largely mixed with sand and small calcareous pebbles, forming a cement which seems to have been baked rather than burned, the heat not being sufficient to fuse or materially alter the pebbles. Some pieces bear traces of what seems to have been glazing. The attempts at ornamentation are exceedingly rough and such as a primitive people first essay by indenting the clay before being baked with the point of a stick or a sharp stone. The large proportion of pottery intermixed with the shells shows that this must have been a permanent settlement—in short, this picturesque bank, with its waving grasses and sweet flowers, is nothing more or less than the refuse heap of some old Indian town. . . . The stone hatchets (commonly known as 'thunderbolts') that have been found have, I believe, been broken or chipped specimens. . . . The shells are such as are still found in Kingston harbor, and the contents of which are to this day used as food; therefore this heap was made at a period not geologically remote. The land shells are all the helix acuta, which is peculiar to Jamaica."

The natives of the Greater Antilles, says a reliable historian, and also of the Bahamas, "were considered by the Caribs to be descended from the Arrowaks of Guiana, a race of Indians to whose noble qualities the most honorable testimony is borne"—and here all inquiry concerning the origin of our islanders seems to terminate. At the time of the discovery, Las Casas computed them at about 6,000,000, but doubtless this is an exaggerated estimate; those of Hispaniola Oviedo estimated at 1,000,000 and Martyr at 1,200,000. They were so numerous that Las Casas says the islands swarmed with Indians, as an ant hill with ants. Edwards, historian of Jamaica, compares them with the Otaheites, "with whom they seem to have many qualities in common." They cultivated large areas in maize and manioc, made immense canoes from the cedar and cottonwood (ceiba) trees, which they gunwaled and pitched with bitumen. They wore a cotton cloth around the waist, most of them, while the Caribs of the southern islands went entirely naked. They were of good shape and height, but less robust than the Caribs; their color, a deep clear brown. All the islanders compressed the head artificially, but in different manner: the Caribs "elevated the forehead, making the head look like the two sides of a square; the natives of the larger islands, the occiput, rendering the crown of the head so thick that a Spanish broadsword would sometimes break on it." It is said to have been a common test of skill among the Spanish settlers as to which of them could most skillfully crack open an Indian's skull or neatly decapitate him. Las Casas testifies to Indians being burned alive and roasted over a slow fire. These things are mentioned as showing some of the causes of extermination, although the chief cause operating was the excessive labor in the mines, initiated by Columbus. And yet, says Martyr, "theirs was an honest countenance, coarse but not gloomy; for it was enlivened by confidence and softened by compassion." We know that they had native songs and hymns, called arietos, an idea of the Deity, as well as a multitude of minor gods; that they made articles of pottery, common vessels, as well as some with adornments; hammocks, chairs of wood (Bartholomew Columbus was presented with fourteen chairs of ebony and sixty vessels, "ornamented with fantastic figures of living animals," when he once visited Anacoana), and obtained gold from the mountain streams. Gold, or the search for gold, was their curse, and their death knell was sounded when, in 1595, all the Indians were divided into encomiendas and repartimientos, and assigned for labor in the field and mine.

Without entering further into detail, the Spaniards are said to have reduced the Indians from 1,000,000 to 60 000 in fifteen years. The only sustained revolt by the Indians was led by a cacique, Henrique, who maintained it for fifteen years, and finally obtained honorable terms of peace. But it was then too late; and though they were assigned a district for themselves, they continued to waste away; in 1535, says Oviedo, not above 500 natives were alive in the island; in 1585, Sir Francis Drake reported not an Indian left alive. Thus we see that their extermination was accomplished in less than a century after their discovery. To-day it is needless to say, not one Indian can be found in that island where the first were found, nor any authenticated traces of intimate admixture of their blood. Not a pure blood Indian was left at Boya, the settlement assigned to Henrique, says an explorer of the last century, Moreau de Saint Mery, in his work published in 1798. . . .

As I have shown already, not a single descendant of the millions—or many thousands—found at the time of discovery, remains in any island of the group. All have perished, leaving behind them only these mute memorials of their former existence here; and all we have to inform us, else, is the scant information to be gleaned from the pages of historians, who, at the best, could not appreciate the value to the present age of ethnological material considered strictly as such. Only in casual manner, and merely as incidental to the historical narrative, are we informed of the most valuable "finds" of Columbus when he discovered this so-called New World.

But although no living link connects the present with the first voyage of Columbus, yet, as we know, there are to-day alive some descendants of the people discovered on his second voyage. It was in 1493 that, sailing farther to the south than previously, he made first land about midway the chain of islands now known as the Lesser Antilles, extending in a general line from Puerto Rico to the north coast of South America, describing the arc of a circle more or less regular, and within the tenth and twentieth degrees of north latitude. Strictly defined, they lie between the twelfth and eighteenth, and are mainly of volcanic origin. Here dwelt the Caribs, a warlike people, who had conquered all who had hitherto opposed them, at the time of their discovery by Europeans, and who had reached as far northward as Puerto Rico, in their devastating advance. The residents of that island, as well as those of Santo Domingo, and even of Jamaica and the Bahamas, were living in dread of their incursions, at the time a more powerful and remorseless enemy appeared, in the shape of the foreign adventurers from Spain. Beyond Puerto Rico, looking east and south, no trace exists of the residence in the lesser islands of the same people who inhabited the Greater Antilles, except in vestiges of subjugated tribes.

Their first reception of the interlopers was a declaration of war, which they sustained so successfully that the Spaniards left them alone for many years, only making descents upon them when they could take them at a disadvantage and enslaving them under an act which allowed the capture and transportation of such as should be proved cannibals. After the enslavement of the rapidly decreasing natives of the larger islands was prohibited, it was most surprising to find how many "cannibals" the Spaniards discovered. I do not think it has been successfully maintained that the natives of the Lesser Antilles were anthropophagous, but as it suited the purposes of the Spaniards to have them declared so, thus they have remained, with that stigma attached to their name, to this day.

At all events, they were too disagreeable for their discoverers to desire further acquaintance with them, except occasionally, and to this fact is due the survival of their present descendants to-day. Taking the islands in sequence, from Puerto Rico eastward, the first group we find is that of the Virgins, discovered by Columbus on that second voyage to America, and so named by him. Were this a narrative of his discoveries, I should like to linger by the way, and point out to my readers the many incidents of that voyage, and describe the islands as I myself have seen them; but I cannot allow myself that pleasure, but must confine my attention to the facts bearing upon the ancient inhabitants and their present remains. I have not discovered, nor have there been found, many relics of the natives of the Virgins differing from those in other islands farther south, and more numerous.

In the island of St. John are some rocks covered with incised figures, which are called the "Carib rocks"—rude petroglyphs without meaning, but undoubtedly of aboriginal origin. Throughout the Greater Antilles, I cannot recall any of these petroglyphs, and they seem to be peculiar to the Carib area, other and finer ones being found in the Island of St. Vincent. The descendants of the Caribs to-day are confined to two islands only, Dominica (which was the first land sighted by Columbus on his second voyage) and St. Vincent. There may be three hundred in each island, but so intimately mixed with the negroes that their distinguishing features are nearly obliterated. They dwell on the windward or eastern coast of either island, in each having a portion of land assigned them, which they cultivate in common, or which at least is not owned in severalty. They subsist upon the fruits of their agricultural labors and the sea, eked out with the scant products of the chase, consisting mainly of small birds, agoutis, and iguanas. Their huts are almost as primitive as at the time of discovery, being constructed of palm logs and thatched with palm leaves. All vestiges of their native religion have apparently disappeared, although they still have a belief in the jumbees and wood spirits of the negroes. They are to-day gentle and easily managed, showing no trace of the warlike spirit of their ancestors; in shape they are robust, well formed, with small hands and feet, and in color decidedly light, and some even fair, their complexion being of a yellowish cast. They make canoes and woven baskets, after the manner of the aborigines, are skilled fishers and sometimes hunters, and are altogether trusty and superior in many respects to the blacks.

Several writers have described the Caribs during various periods in their history since coming into notice, but I will select from them one who wrote about two hundreds years ago, whose pages bear every evidence of honesty and authenticity. At that time the English were mainly in possession of the islands. He says: "They go stark naked, both men and women; though the Christians have conversed very much among them, yet have all their persuasions to induce them to cover themselves been to no purpose. . . . They change their natural color by dyeing their bodies with roucou, which makes them red all over. . . . They also adorn the crown of the head with a little hat made of bird's feathers of different colors. . . . They bore their ears, nose, lips, for the insertion of ornaments. . . . About their necks they wear necklaces made of bones of their enemies, teeth of agoutis, etc. . . . On great occasions they wear scarfs and girdles of feathers. . . . Their most valued ornaments were gorgets of copper, obtained from the Arrowaks by plunder, crescent-shaped and shining, and these are, most frequently, the only possessions they leave their children at death. . . . They wear cottton cloth and can dye it in various colors, chiefly red; they had hammocks when found by Columbus. . . . They made fine pottery, which they baked in kilns, and also wove fine baskets. . . . They cultivated their land in common.

"The Carib boys were compelled to pierce their food suspended from a tree with an arrow, before they could eat it. . . . They are said to have used poisoned arrows, dipping them in what must have been the urrari poison, obtained from Guiana. . . . Like many natives, they eradicated the beard and the hair on other parts of the body. . . . They compressed the skulls of new born infants; and a hatred of the Arrowaks are instilled. . . . Their cabins were built of poles fixed circularly in the ground and drawn together at the top, covered with palm leaves, and in the center of each village was a building larger than the others for public assemblage.

"The Caribbeans are a handsome, well-shaped people, of a smiling countenance, middle stature, having broad shoulders and large buttocks, and most of them in good plight. Their mouths are not overlarge and their teeth are perfectly white and close. True it is, their complexion is of an olive color, naturally; their foreheads and noses are flat, not naturally, but by artifice; for their mothers crush them down at their birth, as also during the time they suckle them, imagining it a kind of beauty and perfection. . . . They have large and thick feet, because they go barefoot, and withal so hard that they defie woods and rocks. . . . They believe in evil spirits, and sought to propitiate them by presents of game, fruits, etc. They believe that they have as many souls as they feel beatings of the arteries in their bodies, besides the principal one, which is in their heart, and goes to heaven with its god, who carries it thither, to live with other gods, and they imagine they there live the same life as man lives here below. For they do not think the soul to be so far immaterial as to be invisible; but they affirm it to be subtile, and of thin substance, as a purified body; and they have but the same word to signify heart and soul. Other souls, not in the heart, reside in the forest and by the seashore; the former they call Mabouyas, the latter Oumekou. . . . They believe they go after death to live in certain fortunate islands, where they have Arrowak slaves to serve them, swim unwearied in placid streams, and eat of delicious fruits. . . . Of the thunder, God's voice, they are extremely afraid. They were prone to leave their houses (huts) after the death of an inmate. It is related, that a young Carib, having been converted to Christianity and taken to France, where he was shown many strange things, at which he showed no astonishment, returned to his tribe, threw off the clothes of civilization, and painted his body with roucou, becoming as wild a savage as before. . . . As to the division of labor, the men made the huts and kept them in repair, procured fish and game, also labored some in the fields; the women attended to the domestic duties, painted their husbands with roucou, and spun the cotton yarn, wove hammocks, etc. They made fire by the friction of two sticks, and torches of candle wood."

Were it not even that we still have evidence of the existence in the Carib area of Indians who dwell here, in the continued presence of their descendants, we should still be enabled to judge somewhat of the state of their civilization by their remains. I have mentioned the existence, in the island of St. John, one of the Virgin group, of rock carvings; near the other extreme of the Caribbean Chain, in the island of St. Vincent, in latitude 13 north, 5 degrees farther south, are several of these strange rocks. I have seen some half dozen of these petroglyphs, in that island, which I visited three and fifteen years ago. Also in the Island of Gaudeloupe, in latitude 16, are several others of similar character. The incised figures represent, rudely, heads adorned with plumes, and other characters are found which cannot be adequately described. These petroglyphs are indubitably of Carib origin, being found only within the Carib area; and so far as I am aware, few, if any similar, have been seen in the larger islands. The characters do not rise to the dignity of hieroglyphics or ideographs, have no coherent sequence or continuity, only a general resemblance. It would be interesting to gather all these and submit them for study to a competent body of ethnologists, but I doubt if great results would eventuate.

More abundant and conclusive in their testimony are the numerous minor objects of Carib art and workmanship, which have been from time to time gathered in the various islands. These remains are in the shape of celts, of jade or jadeite, and serpentine, beautifully polished; discoidal and spheroidal stones, battle axes (these of volcanic stone), semi-lunar and crescentic stones, and many odd shapes as yet unclassified, as axes with notched heads, horn-shaped.

It would certainly be germane to inquire into, and even to speculate upon, the origin of the peoples whose works we have been examining. Without any pretense (as I have said) to authoritative premises, yet I would venture to offer some facts bearing upon the question, with the humble hope that they may aid in the elucidation of the problem of the origin of the West Indian aborigines.

Says the great Humboldt: "When a continent and its adjacent islands are peopled by one and the same race, we may choose between two hypotheses; an emigration from one or from the other. . . . The archipelago of the West India islands forms a narrow and broken neck of land parallel with the isthmus of Panama, and supposed by some geographers to have anciently joined the peninsula of Florida with the northeast extremity of South America. It is the eastern shore of an inland sea, which may be considered as a basin with several outlets. . . . The islanders of Cuba, Haiti, Puerto Rico and the Bahamas were, according to the uniform testimony of the first conquistadores, entirely different from the Caribs. . . . The Caribs, in the XVIth century, extended from the Virgin Islands on the north to the mouth of the Orinoco, perhaps to the Amazon. . . . Those of the continent admit that the small West India islands were ancient-

ly inhabited by the Arawaks, a warlike nation yet existing on the Main. . . . They assert that the male Arawaks were exterminated, except the women, by the Caribs, who came from the mouth of the Orinoco. In support of this theory, note the analogy existing between the language of the Arawaks and that of (some of) the Carib women."

We have seen that historical tradition points toward the southern continent as their ancestral abiding place; let us make another inquiry. . . . Of the animals that constituted their food supply, nearly all the mammals were allied to species or genera of the South American continent. Such were the agouti, peccary, armadillo, opossum, raccoon, muskrat, the dumb dog (now extinct), perhaps the aleo, the yutia and almiqui (of Cuba), and possibly, in the extreme south, a species of monkey. Add to these the iguana, which is peculiarly tropical, the many birds, and the fishes, and we have their entire food supply of an animal nature; saving that the Caribs are said to have been anthropophagous; though I doubt if they were more than ritual cannibals at the worst.

We have seen, also, that the present Caribs of Guiana conform in many respects to those of the islands, and have the same characteristics, preserving their ancient dislike of the Arawaks to the extent of positive aversion. It only remains to quote from a high authority as to their linguistic affinities, to close this summary of points of resemblance. As to the larger islands being inhabited by Indians speaking the same tongue, we may recall that a Lucayan interpreter served Columbus throughout his cruisings among the various islands. Says the authority just alluded to, Dr. D G. Brinton, "the Arawak stock of languages is the most widely disseminated of any in South America. It begins at the south with the Guanas, on the head waters of the river Paraguay, and with the Baures and Moxos on the highlands of southern Bolivia, and thence extends almost in continuity to the Goajiros peninsula, the most northern land of the continent. Nor did it cease there; all the Antilles, both greater and lesser, were originally occupied by its members, and so were the Bahamas, thus extending its dialects to within a short distance of the mainland of the northern continent, and over forty-five degrees of latitude. Its tribes probably at one time occupied the most of the lowlands of Venezuela, whence they were driven, not long before the discovery, by the Caribs, as they also were from many of the southern islands of the West Indian archipelago. The latter event was then of such recent occurrence that the women of the island Caribs, most of whom had been captured from the Arawaks, still spoke that tongue. They were thus the first of the natives of the New World to receive the visitors from European climes; and the words picked up by Columbus and his successors on the Bahamas, Cuba and Haiti are readily explained by the dialects of this stock. The Carib stock is one of the most extensively distributed in the southern continent. At the discovery, its dialects were found on the Lesser Antilles, the Caribbee islands, and on the mainland from the mouth of the Essequibo to the Gulf of Maracaibo. . . . All the island, Orinoco, and Guana Caribs can be traced back to the mainland of northern Venezuela. . . . The physical features of the Caribs assimilate closely to those of the Arawaks. They are taller, in the average, and more vigorous, but their skulls are equally brachycephalic and orthognathic. . . . The Caribs have had a bad reputation on account of their anthropophagous tendencies; indeed, the word cannibal is a mispronunciation of their proper name."

An ancient writer says that this word was first heard off the coast of Haiti—canniba, an aboriginal word, meaning man eater; "And finding in canniba the word can (Khan), Columbus was of the opinion that these pretended man eaters were in reality merely subjects of the great Khan of Cathy, who for a long time had been scanning these seas in search of slaves."

We may deduce, then, from these desultory observations, that these people, so different in many ways, and yet with striking resemblances, had a southern origin; that they were still in the neolithic period, possessing no books, paper, hieroglyphs or ideographs; the rude petroglyphs being their nearest approach to the graphic arts; and there was little promise of that extraordinary development of an indigenous civilization on the lines of advance followed by the natives of Mexico and Central America. They seem to have been isolate from every country and every contact except in the south.

INSECT SECRETIONS.

By E. A. BUTLER, B.A., B.Sc.

THE secretions formed by beetles are of use only to their fabricators, but we have now to consider a family of beetles whose products have for a long time been turned to account by human kind, and made an important article of commerce. This family is the Cantharidæ or Meloidæ, some of the best known members of which are called blister beetles and oil beetles. The family is a very extensive one, containing more than a thousand species already described, which are world-wide in their distribution, though the majority have their home in tropical regions. Of this vast company we have only a very small sprinkling in Great Britain, a select group of nine species, distributed among three genera. Several of the nine are among our rarest insects, and not more than one or two are common. However, this small company contains the most useful insect of the whole family, the renowned Spanish fly, or blister beetle, Lytta or Cantharis vesicatoria.

Nothing more romantic than the life history of the insects belonging to this family can be found throughout the whole range of insect life. The general history of a meloid may be summarized as follows: The eggs are extremely numerous, and on hatching produce very minute six-legged creatures, which have not merely the usual pair of claws at the end of each foot, but in addition a central pad, which looks like a third claw, whence these little beings are often spoken of as "triungulines" (three clawed). They are also distinguished by possessing long bristles at the end of their bodies. They are very active, and their one business is to discover a suitable kind of bee, to whose body they may cling, so that they may be carried away by it, and obtain entrance into its nest. Here the little adventurer devours the bee's egg, and then becomes changed into a fat-bodied, short-legged creature, utterly unlike the little triunguline that produced it. The food of this clumsy larva—for larva still it is, notwithstanding its change of form—is the store that has been laid up by the bee for her own young. By the time this is finished, the larva has lost its legs and become barrel-shaped. But the cycle of changes is not yet complete; other phases have to be passed through before we arrive again at the point from which we started. In the next stage it is a six-legged grub again, similar to what preceded the legless barrel. After this it changes to an ordinary chrysalis, from which in due course the perfect beetle issues.

The great peculiarity in this marvelous history is the existence of two totally distinct types of larva, which succeed one another in time, viz., the active, running triunguline, which reminds us somewhat of the larvæ of those insects that have an incomplete metamorphosis, and the crawling caterpillar-like being which is typical of the larvæ of those insects whose metamorphosis is complete. And here again there is a further complication, this form appearing twice, and its two appearances being separated from one another by an interval during which the creature passes into a form resembling the barrel-shaped chrysalis of a fly. Thus we seem to have in the total twice as many stages as are usually to be met with in the development of an insect.

But our present concern is chiefly with the secretions produced by these insects. The oil beetle receives its popular name from the fact that, when handled, it causes a deep yellow, oily liquid to exude from between the segments of its body, and from the joints of the limbs, a proceeding which makes it a decidedly unpleasant insect to have much to do with. Oil beetles may be found in early spring, crawling slowly about among the grass of meadows, and beside footpaths. They may easily be recognized by their dull bluish-black color, rough, uneven surface, and enormously large abdomen, which is only very partially covered at its base by the shriveled and crumpled elytra, or so-called wing covers, though there are no wings to cover. This ponderous body (speaking of the female insect) trails along the ground as the creature goes on its toilsome way, seeking a suitable place for laying its eggs. The yellow exudation is of an acrid character, and has the power of raising blisters, if applied to the skin in sufficient quantity. For this reason, oil beetles have been used in medicine, especially for veterinary purposes, the chief supply having been obtained from certain districts in southwest Russia. A German writer states that a century ago the oil of these beetles was used in central Europe as a remedy for hydrophobia, and in Sweden it is said to have been employed for the alleviation of rheumatic pains.

While one species of oil beetle (Meloe proscarabæus) is a common insect with us, and may frequently be seen in grassy places in early spring, its more important relative, the true Spanish fly, or blister beetle

SPANISH FLY, OR BLISTER BEETLE.

of commerce, is very seldom met with in this country, though there have been occasions, notably in the year 1837, when it has appeared in profusion in certain localities. Scientifically it is known, as we have already said, either as Lytta vesicatoria or Cantharis vesicatoria, the specific name having reference to its blister-producing properties. It is a beautiful insect, of a shining green color, and with a large square head. By its color, as well as by the facts that its body its comparatively narrow and parallel-sided, and that the wing covers lie side by side and are long enough to cover the body, it may be easily distinguished from the oil beetles, with their bluish-black, stout, oval bodies, and short elytra, which slope sideways away from each other, and so reveal the abdomen between them. It is abundant in many places on the Continent, and the market was first supplied from Spain, whence it became generally known as Spanish fly.

Unlike the oil beetles, the blister beetles are arboreal in habits, frequenting a variety of trees, such as ash, privet, lilac, olive, etc. They appear about midsummer, and during the hottest parts of the day they descend from the trees, and that of course is the best time for securing them. Their presence is pretty easy to detect, for apart from their brilliant color, they emit a powerful scent. Indeed it is said that the characteristic substance to which they owe their valuable property is so volatile as to affect the air immediately around the trees, and thus make it an act of imprudence to sleep under those in which they are abundant. The active principle is called cantharidin, and many experiments have been made with a view to discovering in what part or parts of the insect it is produced, as well as whether or not its production is confined to the adult stage. In the year 1813 it was chemically examined by the French savant Robiquet, who obtained it from the beetles in the form of a white substance in flat crystals, which were found to be insoluble in water, but soluble in alcohol, ether, and other liquids. A chemical formula, $C_5H_6O_3$, has since been assigned to it. It has powerful vesicating properties, for the hundredth part of a grain, when inclosed in thin paper and applied to the lips, caused pain to be felt in about a quarter of an hour, and soon after little blisters appeared. When a salve was applied to these, the heat caused it to melt and run, with the result of carrying the vesicant with it; and thus multiplying the number of pustules, thereby increasing instead of allaying the discomfort.

The experiments of Beauregard were specially directed toward localizing the substance in the body of the insect, and they were carried out by making small plasters of different parts of the beetles and applying them to his own body. His main conclusions were that cantharidin occurred most abundantly in the blood and in certain parts of the reproductive organs in both sexes. Whenever any of the softer parts of the body, still wet and charged with blood, were applied to the skin, they soon produced blisters. Even the elytra, when separated from the living insect, and therefore still containing a small quantity of moisture within their tissues, were found to be capable of causing a similar result. They were applied to the arm by their inner surface, in which the skin would be thinner, and therefore the blood would be more easily able to affect the operator. The dry membrane which thus intervened between the vesicant and the skin of the arm of course retarded the process, but still, after the lapse of seven hours, a good blister was produced. When, however, the elytra were cut up in shreds, and dried with blotting paper, so that all moisture was removed from them, only a very slight effect was produced even by a prolonged application. Thus it was evident that the active principle was to be looked for in the juices of the wing rather than in its solid substance.

The strongly vesicating power of certain parts of the reproductive apparatus of course suggested that the function of cantharidin in the economy of the insect might be connected in some way with the reproductive process. But that such is not necessarily the case evidently follows from the fact that the insect possesses the property to a greater or less degree in all its stages, including those in which it is sexually immature. Even the eggs are possessed of the blistering power, though this perhaps is no more than might be expected, since the ovaries are strongly impregnated with cantharidin. In 1883, Beauregard took a portion of a freshly laid batch of eggs, and working them into a paste with a little water, applied the little plaster so formed to his arm. After four hours, the smarting produced was sufficiently intense to lead him to stop the experiment. He therefore removed the plaster, and a few minutes after an enormous blister appeared on the spot, attesting the strongly vesicating property of the freshly laid eggs. In the larvæ the property was found to be much less intense. Ten larvæ, several days old, were crushed and made into a plaster, which was applied as before. Even after eight hours nothing more than a considerable inflammation was developed, and no blister appeared. When, however, a larger application of the crushed bodies of two dozen similar larvæ was made, a blister was produced after the lapse of the same time.

To collect the insects for medicinal purposes, a plan is adopted which closely resembles that known to entomologists as "beating." A large cloth is spread on the ground beneath the branches of the trees on which the insects are to be found, and then the branches are vigorously shaken, so that the beetles fall on to the cloth.

Being but sluggish in their movements, they have little chance of escape, and are easily gathered up as they fall. Of course they must be killed in such a way as not to damage their bodies, or in any way allow the valuable substance with which they are impregnated to escape, otherwise their commercial value would be impaired. Hence they are killed by means of a weak acid, either by plunging them into vinegar or by exposing them to the vapor of acetic acid. The dead bodies, after being dried, are then stored.

But there are still difficulties to be contended with. As is well known, the dead bodies of insects are a peculiarly attractive bait to various small beetles, which are commonly known under the title of museum pests, and if these once obtain a lodgment among a store of dried Spanish fly, it is not an easy matter to dislodge them. It is vain to hope that the internal doses of cantharidin they are constantly administering to themselves by their ravages will have any evil effect, though this substance, when taken internally by vertebrates, appears to act as a dangerously irritant poison. When the museum pests attack the stores of blister beetles, the amount of damage done is measured simply by the matter actually devoured; for the cantharidin still remains uninjured in such parts of the damaged bodies as may be left, and for medicinal purposes it is by no means essential that the dried bodies should be perfect and entire, though, as we have already hinted, it is desirable that when freshly collected, and therefore moist, they should be in as perfect a condition as possible, lest exudation of fluid, and therefore loss of cantharidin, should take place. But the worst enemy to be encountered is damp, which, though it does not disintegrate the bodies, yet does far more harm than the above-mentioned devourers, since the characteristic properties of cantharidin are lost under its influence.

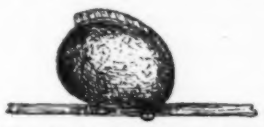
Some insects are gifted with the peculiar power of fashioning receptacles for their eggs, not out of extraneous and foreign materials, which would imply the exercise of a certain amount of intelligence and ingenuity, but from matter derived from their own bodies and used in an involuntary and unconscious way. Special glands exist for this purpose and open into the oviducts, so that the receptacle is formed within the body of the parent, and the insect never sees it till it is finished; hence the eggs are laid, not separately, but in sets, and, as it were, done up in parcels. This peculiarity is specially characteristic of certain groups in the order Orthoptera. In our own country, the cockroaches afford the best illustration of the practice, but in the tropics excellent examples are to be found in the various species of Mantidæ, or praying insects.

The egg cases of the common household cockroach or "black beetle" of the kitchens may often be found lying about in the corners of cupboards, in houses where the insect is plentiful. The case is a reddish brown, horny structure, about half an inch long, shaped something like a lady's handbag, and containing, as a rule, sixteen eggs, of which eight are placed on each side in perfectly regular order, lying parallel to one another. The eggs, of course, hatch within the case, and the young cockroaches issue from their birth chamber at its sharp edge, i. e., what would be the line of opening in the handbag aforesaid, where alone there is a junction.

The material for these cases is supplied by a special gland appended to the reproductive apparatus, consisting of branched tubes, and called the colleterial gland, and the peculiar form is given to the case by the chamber on the walls of which the secretion is spread, and of which it therefore forms a sort of cast. When the whole structure is completed and properly equipped with its complement of eggs, it is still car-

ried about by the mother for several days, during which time it may be seen protruding more or less from her body. It is finally deposited in some safe position, unless the creature is alarmed, when she will sometimes drop it at once.

Our wild cockroaches similarly form cases for their eggs, but as they are smaller than the domestic insect, the cases are much smaller too, and naturally each species has its own peculiar form. Neat and shapely



EGG-CASE OF A SPECIES OF PRAYING INSECT ATTACHED TO GRASS STEM.

though these cases are, they are much surpassed in elegance by those formed by the exotic Mantidæ. These are large and predaceous insects with long and powerful forelegs, which, when watching for their prey, they hold in front of them in the position that has been suggestive of an attitude of devotion, whence the name "praying insects," sometimes applied to them. The egg receptacles of these insects are made of a clear, shining, pale yellowish substance, which is thin and semi-transparent, so that they look as if made of varnished paper or membrane. The surface is indented with a delicate tracery of reticulations, which throw it up into a series of minute rounded elevations. The cases are not left lying about on the ground, but are fastened by a little loop at the lower end to the twigs of trees and the stems of grasses.

The principle of construction is much the same as in the cockroach bags, and so far as external appearances are concerned, may be paralleled, if one may borrow a familiar illustration from the pastry cook, by that of the old-fashioned "apple turnover." As in that article of diet there is a cover whose continuity is unbroken save along a line on one side, where the two edges have been pressed together, and as the ingenuity of the cook seems often to have been expended in crimping and otherwise ornamenting the rim at this line of junction; so we find in the Mantis cases a raised line where the two edges meet, and a very pretty row of markings along it. Within, a partition, which looks as though made of congealed froth, runs across from the line of junction toward the opposite surface, but without reaching it, and the eggs are placed in regular order on each side of that partition, so that they are back to back, and remind one of the arrangement of the cells in a honeycomb.

It is an obvious suggestion that the purpose of these receptacles is to protect the eggs from hymenopterous parasites, many of the minuter forms of which are quite satisfied with the contents of a single egg shell as the total provision for their larval life, so that they pass through their early stages parasitically within the eggs. But that the cases do not always accomplish this purpose appears from a specimen now before me, in which many of the eggs have been devoured by parasites, some of which have reached their perfect condition, and their shining metallic green bodies are still to be seen among the remains of the eggs to testify to the fact of their former ravages.

Taking now a brief mental review of the numerous and varied facts we have described in this series of papers on "Insect Secretions," we may point out one or two general conclusions to which they seem to lead. In the first place, we have the fact that during the lifetime of many insects there occurs a period in which the creature becomes quite helpless, not simply by passing into a torpid condition or a condition of suspended animation, but by the actual loss of its limbs, and with them the power of locomotion, and therefore of escape from danger, and by the abortion of its mouth organs and the consequent loss of the power to take food and sustain active life. Hence arises the necessity for special means of concealment and protection, that the race may not be exterminated when placed at so great a disadvantage with regard to its ever-watchful and never-resting foes. The necessary concealment or protection is afforded in many ways, occasionally by the use of foreign materials, but much more frequently by the production of a substance from within the creature's own body to serve as a cloak of invisibility or a chamber of safety.

But as, in due course, deliverance from this chamber becomes necessary, it is equally imperative that another product should be elaborated for this purpose where mechanical means are not available.

Then, again, insects are usually very small animals in comparison with most of their assailants, and with smallness of size there is, of course, associated a corresponding helplessness against the larger and more powerful. And, though in many cases their speed of locomotion is considerable when we take into account the size of the creatures concerned, yet the rate at which larger distances are covered is extremely slow in comparison with that exhibited by their pursuers, and hence escape by simple speed is usually out of the question; whence arises the existence of numerous secretions rendering them distasteful, or even physiologically hurtful as articles of food.

The development of the social instinct again, involving as it does the association of large numbers of the same species in one spot, necessitates the provision of suitable accommodation for the rearing of large quantities of young. And though this accommodation is frequently provided to a large extent by means of external and foreign matter, we see in the waxen cells of bees a product of the internal physiological processes of their own bodies used for this purpose. And even when the insects are not social, but only gregarious, there is, as we have just seen, provision for the large numbers of eggs produced, the provision on the part of the mothers of cases or sacs which shall supply the place of that maternal care and supervision which in the case of higher animals would probably be rendered.

The shortness of insect life is another important point. As few insects live for more than one season, and the period of activity of some of them lasts over no more than a few weeks, separated by an interval of many months from the next period of activity of the species, the continuance of the race is absolutely dependent upon the meeting and mating of suitable pairs during those few weeks. When the species is gregarious, or so abundant that large numbers are sure to be found within easy distance of each other, there is not likely to be much difficulty on that score. But when the species is solitary or scarce and specimens occur only at considerable distances from one another, special aids seem to be needed to insure the necessary pairings, and it may be that it is for such a purpose that some of the characteristic odors of insects exist.

Finally, in the case of the honey-dew of the aphides, none of the above heads seem suitable as an explanation of its existence.

Here we have a material, not produced on certain special occasions, times of greater danger than usual, but continuously elaborated throughout life. The cornicles from which the drops issue are present in the larval forms as distinctly as in the nymphs or the adult insects. This fact, coupled with the above-mentioned difficulty of ranking honey-dew under any of the heads just enumerated, and with the statement made in a former paper, that no connection has been traced between the cornicles and any special glandular structure, lends support to the theory which makes it an excretion rather than a secretion; or, in other words, a substance elaborated to be got rid of rather than to be used. There is, further, the very exceptional circumstance that it is a substance not merely got rid of by one kind of insect, but also eagerly sought after and used as food by another; and this fact is rendered more striking still by the immense differences, both in structure and life history, that exist between the insects thus associated as producers and consumers, the aphides and the ants.—Knowledge.

PTEROCARYA CAUCASICA.

AT a recent meeting of the Royal Horticultural Society, a conference on forestry matters was held, and a

PTEROCARYA CAUCASICA—LEAF AND FRUIT.

large and interesting exhibition of hardy trees and shrubs was made. The Duke of Wellington contributed nearly two hundred specimens, and from the park of the Duke of Northumberland a large and varied collection were presented. We illustrate a specimen of the Pterocarya Caucasica, of which our engraving is from the Gardeners' Chronicle.

INFLUENCE OF NUTRIMENT UPON THE LENGTH OF THE ROOTS OF PLANTS.

PLANTS, as we know, allow large quantities of water to transpire, or, in other words, evaporate through their leaves. We shall simply recall the fact that a young blade of wheat or rye evaporates a weight of water equal to its own weight in one hour in the sun.

The transpiration is so much the more active in proportion as the alimentation of the plant is poorer. Mr. Hellriegel has found that after a barley plant growing in good soil has elaborated one gramme of dry matter it has evaporated 292 grammes of water. In a soil containing no nitrates it evaporates 867 grammes.

Mr. Deherain has found that ray grass, well supplied with chemical fertilizers, evaporates 233 grammes of water during the time that it is elaborating one gramme of dry material. It transpires 682 grammes in order to produce this gramme of dry substance when it grows in soil that is not fertilized. In clover he has observed that it is not chemical fertilizers that assure the most abundant crops, but rather the ulmic materials. When the soil is supplied with these the evaporation in order to produce one gramme of dry material remains at 255 and 272 grammes, but it ascends to 454 grammes when the soil is destitute of fertilizers, and at 398 grammes when it receives chemical fertilizers only, without ulmic material.

To what is this excessive evaporation of poorly fed plants due? Mr. Deherain has shown by a number of observations that it must be attributed to the enormous development of the roots when the supply of food is inadequate.

I asked myself whether this elongation of the root placed in a medium poor in nutritive material would also occur if the plant were properly nourished by another portion of its roots inserted in a medium rich in alimentary substances. In order to obtain an answer to this question I placed a wheat plant astride of two glass vessels containing nutritive solutions of different composition, so as to be able to compare the two groups of roots with each other.

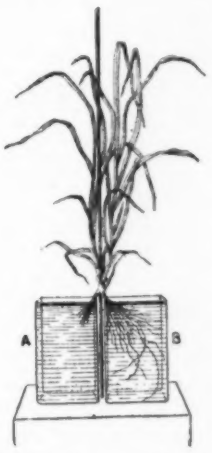
In order to perform this experiment I took up at the end of last April a wheat plant that had reached a height of about 0·2 meter above the earth. With a pair of scissors I cut off the stalk at the place whence the roots spring and placed this amputated stalk upright in a jar containing water of a depth of 0·01 meter. I surrounded the jar with black paper that intercepted the light and placed it near a window in such a way that the green part of the plant should receive the rays of the sun during a part of the day.

By the 10th of May there had started from the lower extremity of the stalk a large number of new roots which were very white and filled the bottom of the jar. This wheat plant, furnished with its new roots developed in the water, was then suspended from a rod fixed vertically to a table. At the right and left of this rod I placed two flat glass vessels like those employed in the construction of electric batteries. I inserted the roots of the plant in the two vessels and divided them as equally as possible between the two. The vessels were filled with cistern water containing in solution the mineral substances that have been recognized by agricultural chemists as indispensable for the development of wheat. The solution contained per liter of water:

Chloride of potassium	1	gramme.
Phosphate "	1	"
Sulphate of magnesia	0·10	"

Wheat is one of the many plants that are obliged to seek in the ground the nitrogenous matter that enters into the composition of its tissues. It was, therefore, necessary to add some to the nutritive solution. I added to the contents of one of the vessels (that to the left, A) some nitrate of potash in the proportion of one gramme to the liter. The vessel, B, to the right, contained a solution without nitrate and consequently without nitrogenous material.

The experiment was made in a non-heated hothouse at the laboratory of vegetable physiology of the museum. The two vessels were completely surrounded with black paper in order to arrest the light, but the green parts of the plant received the sun for a few hours during the day. The wheat plant thus vegetating over the water developed as well as those planted



WHEAT PLANT GROWING IN NUTRITIVE SOLUTIONS OF DIFFERENT COMPOSITIONS.

A, solution with nitrates; B, solution without nitrates.

in the earth. On the first of June I had a photograph taken of it, which is reproduced on a small scale in the accompanying figure.

I think that the reader has already remarked the unequal development of the roots, and has seen that it was in the incomplete nutritive solution in which nitrates were wanting that the roots took on the greatest development. In the complete nutritive solution the roots elongated but slightly. These facts agree with what has always been observed up to the present.

What was curious in this experiment was to find that the entire plant, which was sufficiently nourished by a portion of its roots (since it developed as well as the plants in the open ground), and which, consequently evaporated but moderately, allowed the group of roots immersed in the water without nitrate to assume this very great development.

I believe that I am authorized to conclude that the growth of the root, its elongation, is closely connected with the abundance of food in contact with it. A well nourished plant makes habitually but few roots. Nevertheless, if, as in my experiment, a few of these roots happen to be in a medium which nourishes them insufficiently, they will by that very fact greatly increase.—E. Breal, in La Nature.

MARS.*

By PERCIVAL LOWELL.

THE POLAR SNOWS.

ON "the snowy poles of moonless Mars" the snow remains though the moonlessness has departed. Indeed, difficult as it is to be sure of anything across that great gulf of space that parts us from our closest of cosmic kin, we are nevertheless more certain of Mars' polar snows than of any other physical fact about him.

Conspicuous above every other feature of the planet's disk are two white circular spots covering what rotation identifies as the planet's poles. The two are not, however, commonly in view together, the tilt of the planet's axis hiding the one as it displays more completely the other. At present the south pole is bowed toward us, at an angle of about 17°.

To Huyghens, to whom we owe the sketch of the first recognizable marking on Mars, we owe also the first picturing of these caps. In a drawing of his made at ten o'clock on August 13, 1672, the south polar cap appears unmistakably.

To Maraldi we are indebted for the first study of them. During the opposition of 1719 he observed that the south polar patch, the one then in view, decreased in visibility as time went on, but with apparent fluctuations. During one-half of each presentation† it suffered but slight diminution, while for the other half it grew steadily less conspicuous till finally it vanished. Then in later presentations it as gradually reappeared. From which he argued that its changes were connected with the rotation of the planet, yet in such a manner as to imply physical changes in the spot itself. He, however, likened it to the spots on the sun and to the cloud belts of Jupiter.

In 1777 Sir William Herschel began a systematic observation of Mars with special reference to his polar spots and his rotation, which he continued for four successive oppositions, and the outcome of which was his announcement that these white caps were polar snows, an explanation of them which has received only confirmation since. He based his belief upon the fact that the size of the spots followed in due course upon the Martian seasons. In the springtime of its year each showed as a huge round spot; from which importance it slowly dwindled as summer came on, till by autumn it had decreased to an insignificant patch, which then began to grow again and by late winter had attained to its former proportions.

Sir William Herschel also discovered that the south polar patch did not lie exactly over the pole of the planet; that is, that the pole of cold and the geographical pole did not coincide.

Beer and Madler were the next to extend our knowledge of these far-off snows. They first measured them and their eccentricity; measures which others, including especially Schiaparelli, have since carried to greater perfection. At its maximum the south polar cap is about 70° across, the north polar 60°, and each decreases to a minimum of 4° or 5°. The center of the south polar cap lies about 5° from the south pole in latitude 30°; the north polar one, however, is found to be concentric with the pole. This eccentricity of the southern pole is indeed so marked that it may easily be detected at this present moment by a very small instrument. If the observer will map the position of the true pole on a disk prepared from Marth's data and then look at the planet, he will at once perceive the eccentric position of the little glistening patch which is all that is now left of the superb snow stretch of two months ago.

The size of these winter's night caps of Mars seems to us, at first, huge; but let us try to see ourselves as others see us, if others there be to speculate on the subject. In the depths of winter our own north polar snow cap stretches one unbroken white sheet from the pole to about latitude 45°, in some parts of the northern hemisphere. That is to say, it is in some directions 90° across. To a Martian we must appear to be pretty well snowed under. Indeed, for a time we live in the midst of the snow cap, a pregnant thought toward our conception of life in other worlds.

Curiously enough—unless indeed there be a necessary though as yet unexplained connection between the two—the Martian south pole is apparently the most surrounded by water just as the earth's is, while the winter of the southern hemispheres of both planets takes place when the planets are near aphelion. The latter cause would accentuate the seasons, the former temper them. In the case of Mars the two antagonistic forces would seem practically to balance one another—as the snow accumulates about equally in both hemispheres and melts to about the same minimum in both.

The subsequent history of our knowledge of these snow caps of Mars should be of some interest in view of the extraordinary amount of enthusiasm expeditions to our own north pole excite. For at much less expense and at absolutely no hazard, astronomy has quietly conducted polar expeditions to Mars so successfully that we now know more about the Martian south polar regions than we do about either of our own.

Beer and Madler first observed that a dark band surrounded the north polar spot and continuously. The same has been noticed by Schiaparelli. Oddly enough nobody seems hitherto to have specially remarked that the south polar spot is similarly girdled. The phenomenon, however, is very marked, and the fact that in both the band keeps pace with the spot's contraction is highly significant. For it amounts to proof that these belts are polar seas, quite large in midspring and becoming smaller with the spot itself. How this water disappears is not quite certain; whether it be caught up into heaven and thence descends upon other parts of the planet's surface, which some infer, or whether it runs through long straits to the equator of which we have apparent evidence, certain it is that it leaves the pole only to reappear there the next season.

Though tolerably uniform in width for the greater part of its length, the sea expands in places into broad bays.

But besides this ring of antarctic ocean, there turns out to be at the south pole at the proper season, that dream of arctic explorers, an open polar sea. It lies in a valley between two mountain ranges. Of this we are almost as sure as if we had climbed one of the inclosing summits and looked down upon it.

In 1892 as the snow began to decrease, a long dark line was observed at Arequipa, Peru, to make its appearance in the midst of the cap and then gradually to grow till it cut the cap in two. At the corresponding Martian season this year the same dark line was observed at Flagstaff in the same position. It was well placed for observation and was carefully studied. It started apparently not far from the center of the snow cap and increased in width and length till it opened into the polar sea in longitude 160°. Later its opposite end came out in longitude 330°. Meanwhile it was spreading even faster in the middle. While it was thus eating into the snow, some brilliant points, shining like stars, were observed in the snow between it and the outer edge of the cap—on several successive mornings. They undoubtedly were the far-off glisten of snow slopes. The subsequent behavior of the spots from which they came bore witness to this. For the rift grew till it formed a large lake in the midst of the snow not far from the geographical pole. Other rifts also appeared and ate into the cap, but the spots that had shone out so brilliantly still remained as snow islands, though daily diminished in size. At last the smaller of the two chief portions into which the cap had been split dwindled entirely away and the other became a tiny patch eccentrically placed.

Although the action of the polar snows of Mars is largely like our own, there is one peculiarity about their accumulation which finds no adequate parallel on earth. In 1879 and still more markedly in 1881–2 Schiaparelli observed certain strange filaments of snow spread like long ribbons from the north pole in a spiral southeasterly direction. At this time the north polar cap was quite small, but gradually these filaments contracted upon it, till one day it appeared large and round and the filaments had vanished. This was some little time after the vernal equinox. From the day this metamorphosis took place the polar cap proceeded daily to diminish.

It has been suggested that this phenomenon is what should occur on a planet whose water supply is limited, the precipitation taking place upon an isothermal line that travels with the sun northward.

There is no evidence here of duplication in any of the canals as yet, a result in keeping with Schiaparelli's observations. With inferior seeing a broad canal may appear double, but in better air shows single. An instance of this was observed by Professor Pickering on July 30 in the case of the Ganges, which with seeing 4 to 5 (max. 10) he suspected of being double. Later in the evening, the seeing have improved to 9 to 8, it was seen by him single again and very broad. Schiaparelli's observations have a singular knack of turning out true.

Lowell Observatory, Sept. 12.

* From Popular Astronomy.

† As Mars rotates in about 24 h. 37 m. and the earth in about 23 h. 56 m., this combined with the revolutions of both planets round the sun makes on the average 36 rotations of Mars nearly equal to 37 rotations of the earth. Once therefore in every 37 of our days Mars shows us again the same face at the same hour.

THE SYDNEY COALFIELD OF CAPE BRETON, NOVA SCOTIA.*

By HUGH FLETCHER, B.A., Ottawa.

THIS, the most valuable and most extensive coalfield in Nova Scotia, known and worked for more than 200 years, extends from Mira Bay to Cape Dauphin, a distance of thirty-two miles, being bounded on the north and east by the sea; it has been estimated to contain a land area of about fifty-seven square miles, colored as coal measures and embracing the 1,838 feet of Mr. Robb's maps and reports, or about 200 square miles with the lower seams of the millstone grit, some of which are in places of workable size, and a large sea area; but there is the usual uncertainty of such estimates. The district is intersected by bays and harbors affording fine rock sections in cliffs which rise from 20 to 100 feet above sea level. The coal seams lie in four basins—the Cow Bay, Glace Bay, Sydney Harbor, and Bras d'Or basins—separated by three anticlinals. On the east they are lost in the sea, on the west thrust against the Laurentian rocks of St. Ann's Mountain by a great fault. The carboniferous strata in these basins have been subdivided into four distinct formations—the carboniferous conglomerate, carboniferous limestone, millstone grit, and productive coal measures. The first includes the beds of conglomerate, usually red, found along the foot of the Coxheath Hills. The carboniferous limestone, well exposed at Sydney Point, Point Edward, and Kelly Cove, comprises thick beds of red and gray argillaceous shale and micaceous sandstone, beds of black and gray limestone with traces of galena and copper pyrites, and layers of gypsum here not more than 5 feet thick and unimportant, but largely worked in other portions of the province. On the shore of Sydney Harbor, a little above the South Bar, it underlies the millstone grit and terminates at a fault near the mouth of Freshwater Creek, assumed to be a downthrow to the southwest of about 900 feet. Trunks of trees, fish remains, and shells, indicating brackish water life, are found in a 3½ feet bed of calcareobituminous shale near Sydney Point and Point Edward. These rocks, with the conglomerate, are estimated to have a thickness of 4,637 feet. Beneath them lie igneous and metamorphic rocks of the Coxheath Hills; above them, the millstone grit, separated by a band of siliceous hematite.

The Millstone Grit, about 4,000 feet thick, is well exposed on the roads from Sydney to Cow Bay and Mira Bay on Boulardarie Island, along the shores of Sydney Harbor and elsewhere. In the western portion of the field it consists of an almost unbroken series of beds of gray and rusty coarse sandstone, with great quantities of vegetable fossils, with occasional irregular patches of argillaceous shale and coal; whereas in the east the formation contains thicker and more regular beds of argillaceous shale, with a marked predominance of red shale and sandstone, and seams of coal, one of which at least is of workable dimensions and quality. In this eastern section are the Coal Brook seam of 1 foot 6 inches, the Tracy seam of 4 feet 1 inch and the Round Island seam of 2 feet with smaller layers. Among these beds on the section at Mira Bay are exhibited changes both in color and in essential mineral characteristics. A stratum consisting at one place of coarse gray sandstone is frequently found when followed to no great distance, either on the strike or to the dip, to be replaced by red sandstone or by red or gray argillaceous shale. Such replacements are frequent also in the beds of the coal measures. Trunks and roots of prostrate trees are sometimes found converted into black crystalline carbonate of iron. No beds of limestone were observed in the Mira Bay section, and carbonaceous shales are extremely rare, and where found consist, like most of the coal seams of this formation, of very thin beds composed almost entirely of the matted and pyritized leaves of cordaites. At the north head of Cow Bay, the lowest rocks exposed by the anticlinal in bold cliffs upward of 100 feet high resemble the red, purple and green shales and sandstones of Mira Bay. Some of the sandstones form conspicuous features in the physical geography of the district, constituting high ridges crowned with large loose blocks. Westward from this point the millstone grit rocks are nowhere found on the open Atlantic coast until reaching Cape Dauphin. They form the Bird Islands of the west as they form Flint Island at the eastern end of the district. The formation appears to thin to 1,800 feet at Kelly Cove, while on Mira Bay it is 5,707 feet. On the west side of Sydney Harbor it includes the Ingraham seam, 2 feet thick; on the east side is the Fraser or Mullins seam, 6 feet 4 inches thick, and near McPhee Brook a lenticular layer of argillaceous shale and underclay, 9 feet high, constituting a miniature coal basin. To the eastward there are five seams from 1 foot 7 inches to 2 feet thick below the Lorway seam; on the Cow Bay road, at the intersection of Fitzpatrick Brook, a seam 1 foot 10 inches thick; while another, the Le Cras seam, has been worked on the Mira road by the Messrs. Cossitt and others.

The Coal Measures.—The boundary line between the millstone grit and the so-called productive measures, although important in an economic point of view, is a somewhat arbitrary one, and may be regarded more as a matter of convenience than as of geological importance. As the upper beds are cut off by the sea, the entire thickness is nowhere represented. The productive coal measures include argillaceous and arenaceous shales, for the most part gray, red and green marl, sandstone, underclay, limestone, black shales and coal, a thickness of about 1,840 feet, of which from 40 to 50 feet are coal and 15 feet limestone, one set of seams running through the district. The coal contains more combustible matter than the Pictou coal and a smaller proportion of ash but a greater amount of sulphur, being at most of the collieries less inclined than at the Pictou and Cumberland mines, and therefore not subject to the same proportionate waste in working and screening. Shales constitute more than one half of the total thickness of the coal measures. The argillaceous shales no doubt originally consisted of fine mud, the darker shades being due to the presence of carbonized vegetable remains; some of the beds contain much pyrite and nearly all are charged with clay ironstone in thin regular layers or in spherical or ellipsoidal nodules or concretions. The shales contain a vast variety of fossil plants, chiefly ferns, their most delicate and fragile fronds and stems being beautifully preserved between the laminæ. Many trunks of erect and prostrate sigillariæ with their stigmaria roots attached and growing into the coal seams are also found, the largest nearly 5 feet in diameter, the bark being converted into coaly matter and the interior now consisting of sandstone, carbonate of iron or argillaceous shale. The fluting of the stems is often beautifully preserved, and frequently the leaf scars are visible. Occasionally, the change of argillaceous shale into arenaceous shale or sandstone is so sudden as to give the beds the appearance of being faulted. The red and green marls are argillaceous, of considerable thickness, distributed throughout all parts of the carboniferous series, seldom containing fossils. Numerous beds of sandstone constitute the most prominent, thickest and most persistent members of this series of strata and sometimes form the roof of the coal seams. They are usually of considerable thickness up to 40 or 50 feet, coarse and pebbly toward their base, and sometimes assume the character of conglomerates, false bedding being prevalent in the thicker and coarser grained strata, which are generally charged with casts of plants and much carbonized vegetable matter in conditions which point to deposition in troubled waters, the trunks, stems and leaves having evidently been drifted from a distance and confusedly mixed together. Many of the sandstone beds are calcareous; a bed of this description at Lloyd Cove, near Sydney Mines, furnished specimens of the footprints of a land animal, proving that it was deposited in a flat tidal estuary. Underclays occur immediately beneath every coal seam and bed of carbonaceous shale. They are, for the most part, aluminous and siliceous, form good fireclays, and are copiously charged with the roots and innumerable rootlets of stigmaria ficoides, which constitute the most distinctive feature of these beds; they merge by insensible gradations into the beds upon which they rest and are generally full of ironstone nodules. They vary in thickness from a few inches to 8 or 10 feet, but their size and richness in vegetable remains appears to bear no proportion to the size or purity of the accompanying coal seams. The roots spread themselves horizontally in the beds and sometimes intertwine; they are often flattened and converted into sandstone. The rootlets are generally in a carbonized state and penetrate the bed in all directions, but chiefly downward, as if to prove that they occupy the positions in which they originally grew. The limestones are dark gray or black, vary from ½ inch to 2 feet and aggregate about 15 feet in thickness, are remarkably persistent but disappear or thin out toward the eastern and western extremities of the field. They occupy a definite horizon and are rich in fossils identical with those found at the Joggins, consisting of naiadites, spirorbis, cythere, with scales, teeth, spines and coprolities of ganoid fishes. The fish remains are generally coated with and sometimes entirely replaced by iron pyrites, and the limestone shows cone-in-cone structure. The black shales are sometimes of the nature of cannel or pass into bituminous limestone charged with fossil shells and plants; more frequently, however, they are soft and laminated, seem to be entirely made up of the matted leaves of cordaites converted into mineral charcoal, and may be regarded as

* A paper read before the Mining Society of Nova Scotia.

coarse coals. Many of the workable coal seams inclose layers or bands of such shale, and also sometimes pyritous bands which tend to deteriorate the coal. Taking the average of all the sections measured, the total number of seams in the productive measures is twenty-four, of which six are 3 feet or upward in thickness, and the total average thickness of coal may be stated at 46 feet. The similarity and persistency of the seams over great areas is very remarkable, although local variations are frequent. There is, therefore, no great uncertainty in regard to the equivalency of the various seams at different points. In establishing this there have to be taken into account the quality of the coal, the position and character of the various partings or bands of shaly matter, the mineral and fossil characteristics and the thickness of the strata between the seams, as well as the manner in which the folds and undulations have affected the general structure. In a few instances the coal seams are split by the gradual thickening of their argillaceous partings. Sometimes seams which are of workable thickness and good quality at one place become unavailable at no great distance. In the Blockhouse seam at Cow Bay and the Victoria seam at Sydney Harbor curious wedge-shaped masses of rock, similar to that overlying the coal, interrupt the continuity of the coal. The cleat or cleavage of the coal coincides with the joints of the accompanying sandstones, and is most prominent where the strata have been subjected to the greatest pressure. The coal seams are for the most part overlaid by a stratum of argillaceous shale, very frequently characterized by the occurrence of erect stems of sigallaria, often from 2 to 3 feet in diameter, and in one case nearly 5 feet, the spreading roots of the trees resting upon the upper surface of the coal. Instead of the usual roof shales, the coal is often followed by sandstone, and a bed of sandstone is almost invariably found to overlie the roof shales at no great distance above the coal.

Subordinate Basins in the Coalfield.—Along the sea coast the three anticlinal and four synclinal folds are well exposed, but the upward slope of the strata from the sea causes the coal measures in the latter to rapidly run out inland, leaving large portions of the coal seams to be worked beneath the sea, as at the Sydney and Victoria mines.

The Cow Bay Basin.—The seams of this basin have been exposed both by natural and artificial means on both sides of Cow Bay. The average breadth of the basin at the shore, between the outcrops of the lowest seam, does not exceed two miles and one third, and it diminishes gradually inland until it terminates at a point about six miles from the shore, as proved by several crop pits and boreholes on the various seams. On the South Head some of the lower seams crop out and are cut off by the ocean, thus constituting the eastern extremity of the coalfield as exposed on land. In all the sections at Cow Bay calcareous matter is very sparingly distributed—a remarkable exception to the general rule in this coalfield. On the South Head the coal seams are much more split up by clay and shale bands. The rocks underlying the Long Beach seam belong to the millstone grit. In the center of the basin are the Blockhouse and Gowrie mines, on the south side the South Head colliery.

The Glace Bay Basin.—The axis separating this from the Cow Bay basin skirts the northern shore of Cow Bay at Cape Percy or North Head, the opposite dips being visible in the precipitous cliffs. In striking contrast to the Cow Bay basin, that of Glace Bay is wide and has uniformly gentle dips on both sides; and includes 610 feet of strata overlying the highest beds of that basin, among which occurs the Hub seam, the highest workable coal seam in this district. The attitude of all the seams in the Glace Bay basin, extending for a length of about twelve miles, is a striking proof of the general regularity of deposit and absence of faults which characterize this district; but the section shows considerable thinning of the beds between the several coal seams as they are traced westward. The most important cannel coal found in this field lies 25 feet beneath the Hub seam, is 1 foot 2 inches thick, underlined by 9 inches of ordinary bituminous coal and by 1 foot 9 inches of coal, clay and carbonaceous shale in eleven bands; attempts have been made to work it, as it contains 30·07 per cent. of volatile combustible matter, 44·42 fixed carbon and 24·68 ash. In the Phelan seam, at a distance of half a mile from the shore, in the main level of the old Bridgeport mine, a shale parting has increased to 28 feet. The Ross seam at and near the Bridgeport shore is only 1 foot 8 inches in thickness, while at the Emery mine, not quite two miles and a half to the eastward, it averages 5 feet 3 inches. Situated in the Glace Bay basin are the Schooner Pond, Ontario, Caledonia, Glace Bay, Emery, Reserve, Lorway, Gardener, International and Bridgeport mines.

The Sydney Harbor Basin.—The next basin includes the Lingan, Barasois, Low Point and Sydney mines districts, extends from Indian Bay and Bridgeport Basin to Point Aconi, and embraces all the coal seams in the field. An anticlinal axis which skirts the north shore of Bridgeport Basin and runs thence westerly, parallel with the North Head anticlinal, to a point midway between McPhee and McKay Brooks on Sydney Harbor, divides this basin from that of Glace Bay. On the north side of this axis the rocks dip at angles varying from 12 degrees to 16 degrees at Lingan to 40 degrees at Victoria Mines. From Lingan to Low Point lighthouse the strike is nearly parallel to the shore, and brings the entire volume of the coal measures upon the cliffs in several fine sections which show 349 feet overlying the highest strata of the Glace Bay section; and the exposures on Sydney Harbor are equally fine. The Lingan, Victoria, Sydney and Collins mines lie in this basin.

The Bras d'Or Basin.—West of the Little Bras d'Or, a low broad anticlinal running from Point Aconi to Saunders Cove deflects the strata to the south to form this basin, which includes the Boularderie and Cape Dauphin districts. On the northwest side of Boularderie Island the coal measures are exposed in an unbroken section, extending, in the direction of the dip, over a distance of about six miles, from Point Aconi to the millstone grit, which here include two coal seams not workable. In the Boularderie district the coal has been very little developed. In the Cape Dauphin district only the lower part of the productive measures, probably as high as the horizon of the Sydney Mines main seam, is developed; the principal seam worked at the New Campbellton mine is the continuation of the Blackrock or Number Three seam of the Sydney Mines section, and that underlying, cut in a vertical attitude in the tunnel near the mountain, is the equivalent of the Collins seam of the Little Bras d'Or. The Blackrock and New Campbellton collieries are situated within this district.

[FROM THE INDEPENDENT.]

KILAUEA VOLCANO SEEN ANEW.

By the Rev. SERENO E. BISHOP.

I HAVE just got home from a fresh visit to Kilauea, having there taken in a new aspect of its surging lake of fire. It impressed a vivid and terrible vision on the retina, of which I would tell.

Several of us had driven that day southwest from Hilo town and harbor, thirty-one miles. We had been seated over six hours in the comfortable four-horse stage. The road was superb, smooth, hard, of easy grade. More than half the way had been through magnificent forest, filled underneath with the splendid feathery fronds of the tree ferns. We had almost imperceptibly risen to an altitude of four thousand feet. The sharp summits of Mauna Kea rose boldly on our right, the grand dome of Mauna Loa confronted us—each fourteen thousand feet in height. Our last mile was on level ground, ending at the brow of a somewhat rapid descent into the district of Kau. There stood the rather pretty and very commodious Volcano House, on which we came quite suddenly.

Only as we drove up to the door was suddenly disclosed at our feet the immense caldera of Kilauea, its black floor stretching far away to the southwest. The abyss yawned deep below us. All around was rich vegetation and rank ferns. Then a precipice fell sheer six hundred feet. At the bottom was a black desert of recent lava overflows covering an area of six square miles. Two miles away rose unceasingly a dense column of white vapor, marking the site of the fire lake. There for thirty years past the outflows have been pouring out, and spreading over the caldera, until they have heaped up a very flat kind of cone, which is little more than one hundred feet below the level of the hotel. When I saw it forty years ago the depth of the caldera was uniform throughout, a level plain. Now the further end is swollen high above the rest.

Mine host, Peter Lee, a genial Norseman, helped us alight. "Mr. Lee, I must return in the morning; can you send me down the crater at once?"

"Yes; a party are just going down; you will have a cup of tea first; then I will have a good mule ready for you."

We started at five P. M., three ladies on "stride" saddles, four men mounted, besides one on foot, and the guide carrying lanterns for the return trip. We made fast time down the well-graded descent of six hundred feet, where we struck the black floor of knotted and humpy rolls of lava. An easy trail had been built over this since my visit two years before. We trotted rapidly on, crossing a rustic bridge over a chasm, and ascending the great lava flows of 1891. After one and a half miles of this, we left our animals in a little stone corral, and kept on afoot another half mile over the new lava of last May and June, rising about two hundred feet in that distance. The lofty brown walls of the caldera of Kilauea stretched far away around us on either side. The knurled and knobby rock under our feet grew warm. Steam rose from crevices at every step.

Suddenly, without premonition, we stood upon the rim of a horrific abyss, in whose depth lay the terrible fires of Halemaumau. From the lips of each newcomer broke the same irrepressible Oh-h! How many times I have heard that. It is a cry of wonder and horror. Deep below, vast, mighty, fearsome, lay the great burning lake. A dull red crust veiled the glow of its ten acres of surface. Bursting through this crust were playing here and there huge fountains of molten magma, the roar of whose surging came up to us. Stretching in every direction across its eight hundred feet of breadth glowed brilliant lines of crevice, creeping slowly from side to side, zigzag and crinkled, greatly resembling the lines of chain lightning, only not transient like them, though constantly but slowly changing.

The fire fountains call for careful description. Of these there are three classes. In the present fire lake, which dates from since the collapse of March, 1891, is a single large fountain of the first class, situated east of the center of the lake. It has a pulsating action, coming up two or three times a minute. It swells up in a huge blob or bubble, breaking and dropping with a heavy, crashing thud, driving a billow of fire in every direction. To the untrained eye it resembles in size a large haycock. Instrumental measurement shows it to vary from forty to fifty feet in diameter, and about thirty in height. By its persistent uniformity of action, this fountain has earned the name of "Old Faithful."

South of this, midway to the edge of the lake, is a group of active fountains, which commonly unite in one. This is of the second class. When in full action, an area of sixty by twenty feet forms a massive surge of tossing spray twenty feet high. This tossing up of the fire lasts several minutes, followed by longer intervals of quiet. A similar but much larger fountain is located west of "Old Faithful," again midway to the edge of the lake. This covers a space of one hundred and twenty by thirty feet, forming a constant mass of tossing spray thirty feet high. Spurts of fire are flung up one hundred feet. This spraying is accompanied with violent roaring. Like its sister fountain, it is very intermittent and irregular in action, though lasting often fifteen or twenty minutes.

A third form of fire fountain, and often terribly violent, appears at various points on the edge of the lake. These are points toward which a current sets on the surface. The current carries with it the crust. This is spongy, composed of numberless glassy vesicles filled with air or steam. As the crust approaches the edge, down into which the current plunges, great slabs of crust tilt up and dive below to their fiery doom. Ingulfed for a moment, the vapor contained in their vesicles is at once intensely heated and expanded. A violent explosion follows. A great body of the fluid fire blows high into the air, often with huge pieces of the dark crust. Down again is sucked molten fire and crust, and out again is vomited the dose. So the play goes on, and the lava spray flings high aloft.

I was strongly impressed by the strange persistence of the three fountains first named. They seem precisely identical in their style of activity and in their position in the lake with what they were in April, 1892. This persistence seems strange, when we consider the great changes which the lake has undergone since that date. It rose four hundred feet, and then subsided over six hundred. Meantime it filled up and built out a mass of solidified lava containing more than fifty million cubic yards of rock. Now it has settled much below what it was in 1892, carrying down with it several million cubic yards of rock which have melted up in its depths after floating for a while as islands; yet we find the same three fountains playing as they did before. The interior mechanism which maintains such uniformity of action is difficult to conjecture.

Another wonderful persistence is shown in the way in which the lake has maintained the same outline or contour during the changes of level described. The many photographs made, as well as my own pencil sketches in 1892, have made this outline familiar. It approximates a circle, but is somewhat lenticular, with certain large indentations. I was surprised to observe that the outline of the lake continued to be substantially the same. It had much the same outline when it stood for months of last spring brimming over the top of its built up cone, and flooding the upper floor of Kilauea. The lake, in growing upward, evidently built up its shaft or well so that it preserved the same section throughout.

A short history of the lake is in place here. The inner crater of the volcano, known as Halemaumau, occupies a nearly circular area of about half a mile in diameter. Within this area the lava rises and falls, frequently overflowing and building up the main floor outside. In March, 1886, after some years of overflowing, Halemaumau collapsed. The lava broke through the shaft below and forced its way under the slopes of land southwest. The built up sides of the crater fell in, leaving a dark, gaping pit, half a mile in diameter and of great depth, the bottom filled with smoking rock ruin. Very slowly the fire arose again in the pit. An underground lake floated up on its bosom an enormous mound of the old debris. Around the sides of this mound appeared several small open lakes. The largest and most accessible of these, one and a half acres in area, was christened Dana Lake, on the occasion of the eminent geologist's visit in 1887. The lava and the great mound continued to rise, until by 1889, the rim was surmounted, and again for two years vast overflows built up the upper floor, raising the rim of Halemaumau about fifty feet. From this rim the floor of Kilauea stretches away on all sides at an easy grade.

Exactly five years to a day after the collapse of 1886, in March, 1891, a second collapse took place. The whole lofty mound suddenly fell into the depths; the same deep, half-mile-wide pit yawned as before. A considerable earthquake accompanied this collapse. It was a peculiar fact that this was simultaneous with a hurricane of extraordinary violence in Kusaie, three thousand miles west, which was attended by great barometric perturbations here. Such changes of atmospheric pressure upon the earth's surface evidently tend to excite displacements in its crust, causing seismic tremors.

This time the lava promptly returned in great force, rising steadily. When I saw it in April, 1892, it occupied the center of a black floor which it had made for itself, in the bottom of Halemaumau. The great pit was three times the diameter of the eight hundred foot lake. The perpendicular walls were three hundred and twenty feet down to the level of the lake. The same fountains were playing as described above. All that year and the next the lake intermittently rose higher and higher. After a time the frequent small overflows, as it brimmed over, formed a narrow dam some thirty feet high around its whole periphery, while the new floor around it sloped away toward the sides of the pit. In this condition, its form closely resembled the surface of an inverted saucer. Visitors would descend the pit and clamber up the low dam, and thrust poles into the molten lava. Seldom an hour passed, but somewhere it would brim over the dam, often in a great torrent, a piece of luck to the fortunate spectators, if they were not compelled to an unpleasant activity in escaping the hot gush.

By the beginning of the present year this inner cone, with its brimming lake atop, had surmounted the upper rim of the pit, and soon buried it in its overflows. The heavy winter rains no doubt increased the activity of eruption, as the waters percolated deep down and leaked into the shaft of fire. There was enormous overflow. The lake built itself higher and higher on its inverted saucer top, until it lacked only seventy feet of the level of the hotel floor. Floods of bright metal were constantly pouring over on one side and another. Even then the visiting went on, and tourists would clamber up and toast their faces peering over the edge.

Early in July a third but only partial collapse occurred. Some part of the bottom dropped out. Down, down sank the lake. The sides of new rock, left unsupported by the heavy liquid, began to fall in, with heavy shocks and great clouds of dust. Everybody rushed down from his breakfast, among them Minister Thurston and General Armstrong's brother Nevius. What they saw baffled description, as pile after pile of rock broke down into the lake, driving its surges far aloft. The level of the fluid sank to a great depth. The infall of the sides did not, however, involve the great area of the original pit which had been filled. There is now a pit larger than the lake, but only fourteen hundred feet wide, or a little more than half the diameter of the former pit.

This smaller present breadth makes the great depth of the pit far more impressive and terrible than ever before. After making careful comparisons of the height of the walls with the known breadth of the lake, I arrived at the conclusion that it was nearly or quite six hundred feet down. This is much more than others have called it. It is a most hideous and terrible well of fire. I have never seen any sight so grand, so dreadful. One seemed to be looking down into the fiery depths of the heart of the globe and searching out the terrible secrets of its molten interior. There was something of the colliding and clash of the gigantic inner

forces which gravity has imprisoned within this thin smiling earth crust on which we so securely and unthinkingly disport. There those forces are slightly unsealed to our quailing vision.

Before an hour had passed the darkness began to close down, and the brilliance of the fires to blaze forth. Heavy clouds of vapor often obscured the sight. It was seldom that the whole lake could be seen at once. The vapor was innocuous—pure steam, with a faint whiff of sulphurous acid. High up around the cliffs shone out incandescent points of light, recesses where still molten lava lingered, preserved from cooling in the spongy, non-conducting rock. Every few minutes fragments of rock would scale off the cliffs and dash down toward the lake. A considerable mass plunged in on the opposite side. An enormous surge arose, splashing high upon the talus of the cliff and saturating the loose pile of rocks with fire. Out from their interstices for some minutes continued the living fire to pour, in streaming cascades, over a breadth of sixty feet in width and height.

These night views of the lake and its fountains have an immense fascination. The brilliance is intense. The play of fountains and crevice gleam is constantly varying. Fire is alive in giant might and activity. It is in colossal play, foaming, flinging, tossing, surging. It is always hard to tear away from the spectacle. Two of us who had often seen it, and a mother who yearned to be back to her babe, tore ourselves away early, and, trudging and riding by lantern light, reached our inn at nine o'clock. The others came in after ten; telling how, after we left, the whole surface had broken up into a glorious, tossing sea of fire.

It is the regular thing for the evening parties from the crater to get a hearty ten or eleven o'clock supper. Sometimes, when very tired, we first take a hot steam sulphur bath. The nights are chill at that latitude, and when the house is full, as it was that night, the three parlor fireplaces are burning merrily, as indeed they do much of the cool day hours. During this summer, a large number of island residents have tarried at this delicious upland retreat. Foreign tourists are more numerous in the winter. Now that the splendid road from Hilo is complete and the journey up is converted into a delight, both residents and foreigners will be attracted in greatly increased numbers.

Our good government has been getting on securely and comfortably these few weeks without the protection of any United States warship. The Charleston is now calling here for coal, en route to China. Three German ships have come in on a like errand. The fallen queen is still pretending to the ignorant natives that Mr. Cleveland is going to restore her, and that all of them who take the oath for the republic will be hanged when she returns to power. This farce cannot last much longer. It may avail to deter a majority of the natives from registering in time to vote at the election near at hand.

IMPROVED HYDRAULIC CAPSTANS.

By ARTHUR RIGG.

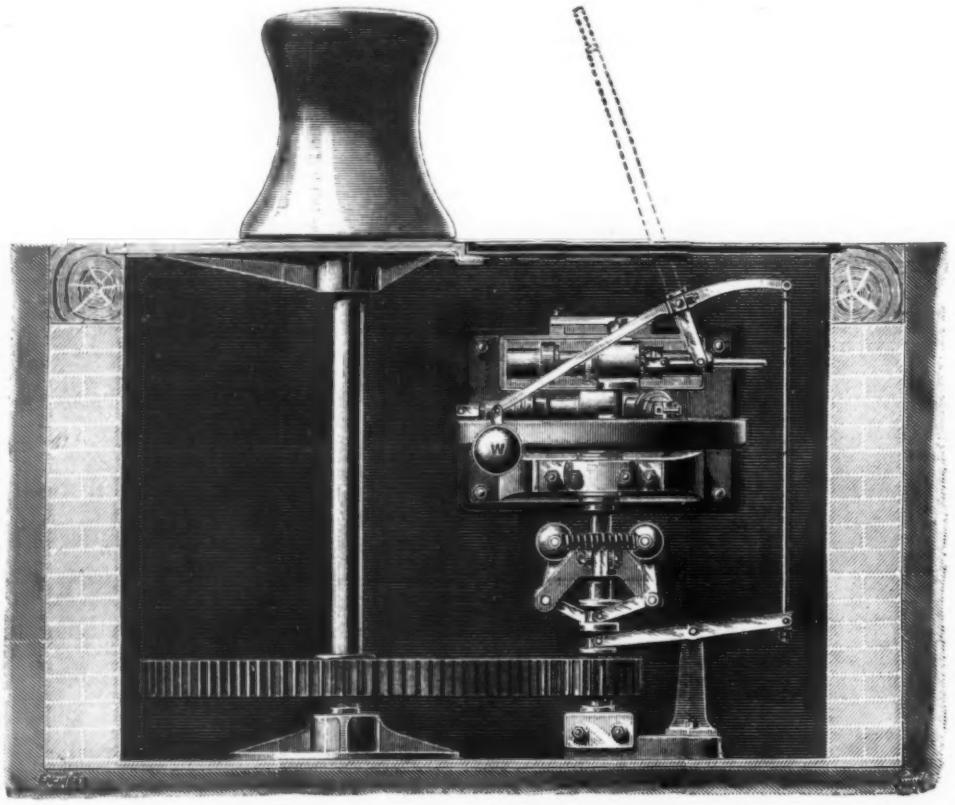
HYDRAULIC capstans as hitherto constructed are wasteful in their use of pressure water, actually taking more when running unloaded than when performing their full work. It is mainly from this cause that there has been comparatively little extension in the use of hydraulic engines, and as the governing arrangement now to be described proportions the quantity used according to the demand for power, there is now no further reason why the application of these useful and convenient motors should not become greatly extended.

The hydraulic power supply companies practically restrict their sphere of operations to working lifts and cranes, as their pressure water is so much more costly than gas or steam power, and few opportunities occur where this convenient but costly power can be used for anything else. It does not seem to have occurred to these companies that it might pay much better to supply a cheaper power for a more extended class of customers than to keep up the out of date system of high prices and restricted output. As if to handicap still further the use of such hydraulic engines as have been hitherto put up, they use the same quantity of water when running at the same speed whether there be a full load or none, thus comparing in extravagance with a steam engine provided with a throttle valve, and using steam throughout its stroke. Any arrangement, therefore, by which the stroke can be altered in proportion to variations in load improves the economical working of hydraulic engines much as the working of steam engines was improved when an earlier cut-off gave the advantages derivable from expansion. What with the original high cost of water pressure and its wasteful application, it is not surprising that hydraulic engines have not, up to the present time, become generally used for obtaining power, although their extreme convenience as compared with gas engines or steam engines is allowed on all hands. Before a governor can be applied, it is necessary to arrange for a variable stroke, which cannot well be managed with an ordinary crank. A reduction of speed seems the simplest method for regulating power, but as a uniform speed is so generally required, very few cases occur where this plan can be followed. For cranes or hoists regulation may be carried out by providing two or more rams and a system of valves, whereby one or more rams can be put into action, thus giving relatively proportionate powers. Such systems, however, are inapplicable to engines turning shafts, or at least they would be so inordinately costly and complicated as to preclude their general use, and an alteration in stroke remains the sole convenient and practical method whereby hydraulic engines can be satisfactorily regulated, and the speed maintained at a uniform rate.

In spite, however, of such drawbacks accompanying the use of hydraulic engines, great numbers are used at railway stations, docks, and other places, for driving capstans, and the surpassing convenience of such an unfailing power, so easily distributed, is found to compensate for the waste attendant upon its use. In order to mitigate, in some degree, the losses which occur when such capstan engines are running unloaded, it is usual to design their ports and passages extremely small, so that friction through them shall prevent too rapid a current, and also shall limit the speed at which the capstan can run when unloaded. Then the reciprocation of their rams frequently reverses the current of water, and this operation entails a series of destructive shocks upon the engine. Nevertheless, the combined effect of insufficient passages and the reversal of currents at a tremendous pressure imposes a limit—of utterly unscientific and wasteful character, it is true—upon the speed at which such capstans can be driven.

Capstan engines are made with two rams, having cranks at right angles, or with three cylinders, acting on the same shaft and cranks at 120°, so that they will start when water is turned on, and their dimensions are such as to provide an ample reserve to start a load beyond the nominal power at which they are intended to work. If we take the case of a capstan engine driven by three single acting engines set radially around the same crank and at 120° to each other, it is well known that the crank receives a tolerably uniform tangential effort, and a fairly regular movement ensues. But because of the crank turning round it is highly inconvenient to alter its radius, for this has already been attempted with results by no means successful from a practical point of view. If, now, we regard the same three cylinder engine as having its crank centers fixed, so that when pressure is turned on the pistons will drive the capstan by revolving round the main shaft center while the cylinders revolve around the crank center, we get exactly the same results as to power by the ordinary system, with more than one very distinct advantage. As the crank has now become stationary, it is easy to move its center nearer or further from that of the main shaft, and all difficulty as to its regulation is at an end. If the crank centers be 3 in. apart, then the stroke becomes 6 in.; but if these centers be closed together until only 1 in. apart, then the stroke becomes 2 in., and there is the further utility in being able to alter the stroke, that by transferring the crank center to that opposite the main shaft the engine reverses.

Having secured this mechanical convenience, it is no longer necessary to contract the area of water passages, for these can be made as large as desired, and the arrangements for governing, by altering the stroke, are all that remain to be carried out. There is now no appreciable loss by friction, and the full pressure may be admitted under the rams, and the speed can be maintained constant, while the power can be regulated in a thoroughly scientific manner by causing the stroke to vary as the governor balls move in or out. As a considerable pressure is required to move the center carrying the cylinders, it is necessary to provide a supplementary engine, as a "relay," to perform this duty, leaving the governor to move its valves and so determine how long the stroke shall be with any current load, and the engine running at any predetermined speed. The method by which this operation is carried out is shown by the accompanying illustration.



RIGG'S IMPROVED HYDRAULIC CAPSTAN.

This figure shows a three-ton capstan driven by a revolving engine, with the general arrangements of its governor—an apparatus of any ordinary kind. When the intended speed has been reached, the governor balls extend themselves, and through the intervention of levers and connecting rods, the valves of the subsidiary engine are actuated, so as to shorten the stroke of the main engine until it runs at any speed for which the governor has been arranged. The same speed is kept up while winding slack rope, and as this can now be made much faster than usually permitted with other capstans, a very adequate control is maintained and the capstan quickly gets hold of its load. As the rope tightens speed reduces, and the governor balls close together, permitting the weight, W, to descend and act upon the valves of the subsidiary engine in such a manner that the main engine has its stroke increased, and the hauling power of the capstan shows a corresponding augmentation, even until its full available power may be brought into operation.

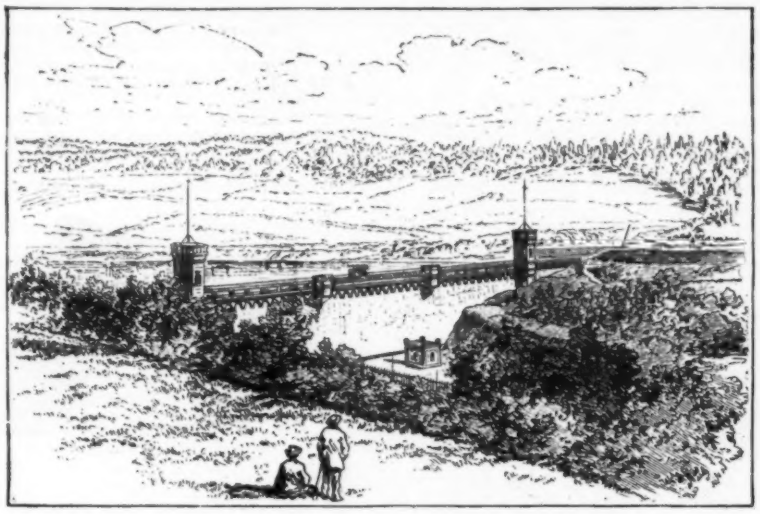
In hauling vessels, a curious effect is shown by the capstan running at a high speed at about one-third stroke while drawing in the slack rope; then it acts with full energy until the load begins to move, and afterward keeps changing between its shortest and longest stroke, as the cable tightens or slackens. Thus the governor keeps up a constant watch, and always regulates the stroke according to the load, however that may alter. As the capstan runs unloaded at one-third stroke, it may fairly be assumed that the average quantity of water used will, at most, be under one-half of that which would have been used had the hydraulic engine been unprovided with any governing arrangements. As three tons, moved at the rate of 60 feet per minute, requires at least 20 horse power exerted by the main hydraulic pumping engines, it is obvious that any contrivance by which this demand can be reduced to one-half represents a somewhat important economy, and one that justifies any additional cost of a secondary engine, with its valves and governor, to gain. It means a saving of one-half the existing engine power, or doubling the number of capstans that might be employed on a railway or docks driven by the same power; and as it is well known current expenses very soon represent an enormous interest upon capital, such a saving at so moderate an expense is a thing that, in the present days of keen competition, no company can afford to neglect.

It is sometimes useful to have the power of reversing a large capstan, particularly when new cables are being used. These sometimes acquire a kink which cannot be quickly released, and it may become necessary to cut and sacrifice a new cable to let a vessel go free. By reversing the capstan, however, a cable can be released, and the handle—shown dotted—is intended for this purpose. The governor acts only for the usual direction of hauling, but does not act when reversing is adopted for a few moments in order to release a cable. As there are no reversals in the direction of currents when driving one of these engines, it follows that there are no severe shocks in running, and this fruitful cause for the destruction of packings, if not for the breakdown of engines, is absent in those of the revolving type. If the water should not be flowing into one cylinder, it will be flowing into another, and that which is in any one cylinder when the inlet closes revolves with it at considerable velocity, and in no case is brought to rest, as in any other type of engines with reciprocating pistons. It is this evil caused by stopping and starting a column of water which so quickly injures the packings of these engines where such shocks occur. In the revolving type either cup leathers or ordinary packing glands can be used, and both are found extremely durable. The cylinder bosses and valve faces are somewhat peculiar in their construction. Their external packings are made of hydraulic leather, and there is a piston within the boss of that cylinder which is furthest from the valve face for the purpose pressing all the bosses together, and for resisting any pressure against the face of No. 1 cylinder that would tend to force it away from the valve face. By the operation of such a balance piston, all the cylinder faces are retained in proper, easy contact, and waste is prevented.

These engines have been running for many years, and although the relay engine, with its valves and governor, may seem somewhat complicated to those who see it for the first time, these additions are by no means so intricate as the Corliss or any other gear used for a like object—the economizing of power in the use of steam; as the cost of water power from an accumulator is necessarily greater than that of the steam power by which its pressure is obtained, it follows that the economical use of water is of correspondingly greater consequence than the economical use of steam.—The Engineer.

THE NEW DAM FOR THE CHEMNITZ WATER WORKS.

THE chief manufacturing town of Saxony, the world-renowned Chemnitz, has increased so rapidly during the last ten years, both in the number of its inhabitants and in area, that it seemed probable the water supply would soon prove inadequate, and, therefore, in 1890 the city government decided to increase the supply by building a dam across the valley at Einsiedel, and 1,300,000 marks ($309,400) was appropriated for this purpose. The structure consists of an immense wall built diagonally across the valley, so as to form a great basin in which the water of this valley and the neighboring fish-breeding valleys can be collected and made available for the water supply of the city. Chemnitz has now 150,000 inhabitants, and requires an average of about 1,849,190 to 3,434,210 gallons daily, according to the season of the year, and with this new dam the supply should meet the increasing demand.



THE CHEMNITZ WATER WORKS.

The corner stone for the dam was laid on November 7, 1890, and the preliminary work was carried forward so rapidly that in the spring of 1891 work was begun on the wall proper and also on the labyrinth of underground filtering chambers, of which nothing is now visible but the air shaft and the entrances. After three years of constant work the dam was completed last spring, and on June 12 the basin was filled.

Near the surface of the water the wall forms a curve with a radius of 1,312 ft.; its length at the top is 7,086 ft.; its height above ground is 65 ft.; and in the deepest part it extends 26 ft. underground. It is 65 ft. thick at the base, 46 ft. at the surface of the ground, and 13 ft. at the crown. This immense piece of masonry is built of quartz slate, hornblende slate, and clay slate, with cement and lime mortar. The wall is covered with a 7 in. layer of beton, and over this there is a layer of asphalt. On the water side the part underground is covered with a layer of beton 11 in. thick, and the part above ground with cement 0·9 to 1 in. thick.

This dam forms a mighty mass of stone between the steep sides of the valley, and is ornamented at each end with a tower. The top of the wall is finished with a frieze resting on consoles. The parapet is of red brick, and the mouldings of granite and sandstone. The parapet is broken by bartizans. This immense structure incloses a basin of 12,712,916 cu. ft.; the surface of the water is 8·9 acres, and the greatest depth is 61 ft. 6 in., and it drains a region 667 acres in extent. The average quantity of water delivered by it each year will be 211,336,000 gallons.

To prevent overloading of the basin by an unexpectedly heavy rainfall, a gate has been built that is 82 ft. wide, with a sluice 28 ft. wide and 5 ft. deep, that can carry off 7,925 gallons per second. The water stored in the reservoir can be let off by means of a sluice at the bottom, but for the ordinary supply the water will be taken from the middle of the height through pipes that can be closed, to the three filters, in which it passes through systematically arranged layers of sand, pebbles and stone, which cleanse it of all impurities, and then it flows to the reservoir. From there it flows, with a natural fall, to the high reservoir of the city, joining on the way the tributaries from the side valleys and the water of the old water supply.—Illustrirte Zeitung.

[FROM THE TECHNIC.]

ENGINEERING FACTS.

ENGINEERING is generally considered an exact science, and if we fully understood all the conditions under which the observations and experiments were made, the results of which we are often obliged to accept on faith, it would be strictly true. It is an unfortunate fact, however, that our reference books have many examples of the determination of so-called physical facts, which, although correct for the circumstances under which the observations were made, are absolutely worthless for a basis in designing engineering works, for the reason that the relative conditions are unknown. It is therefore very evident that in accepting results from any authority as a basis for engineering design, we should know whether the conditions under which such results were obtained were identical with those where it is proposed to make use of them, and if not identical, what will be the probable effect due to change of circumstances.

Two engineers may test the tensile strength of concrete made from the same barrel of cement, and obtain results differing over fifty per cent., either of which might be very misleading if the methods of conducting the experiments are unknown, as is often the case.

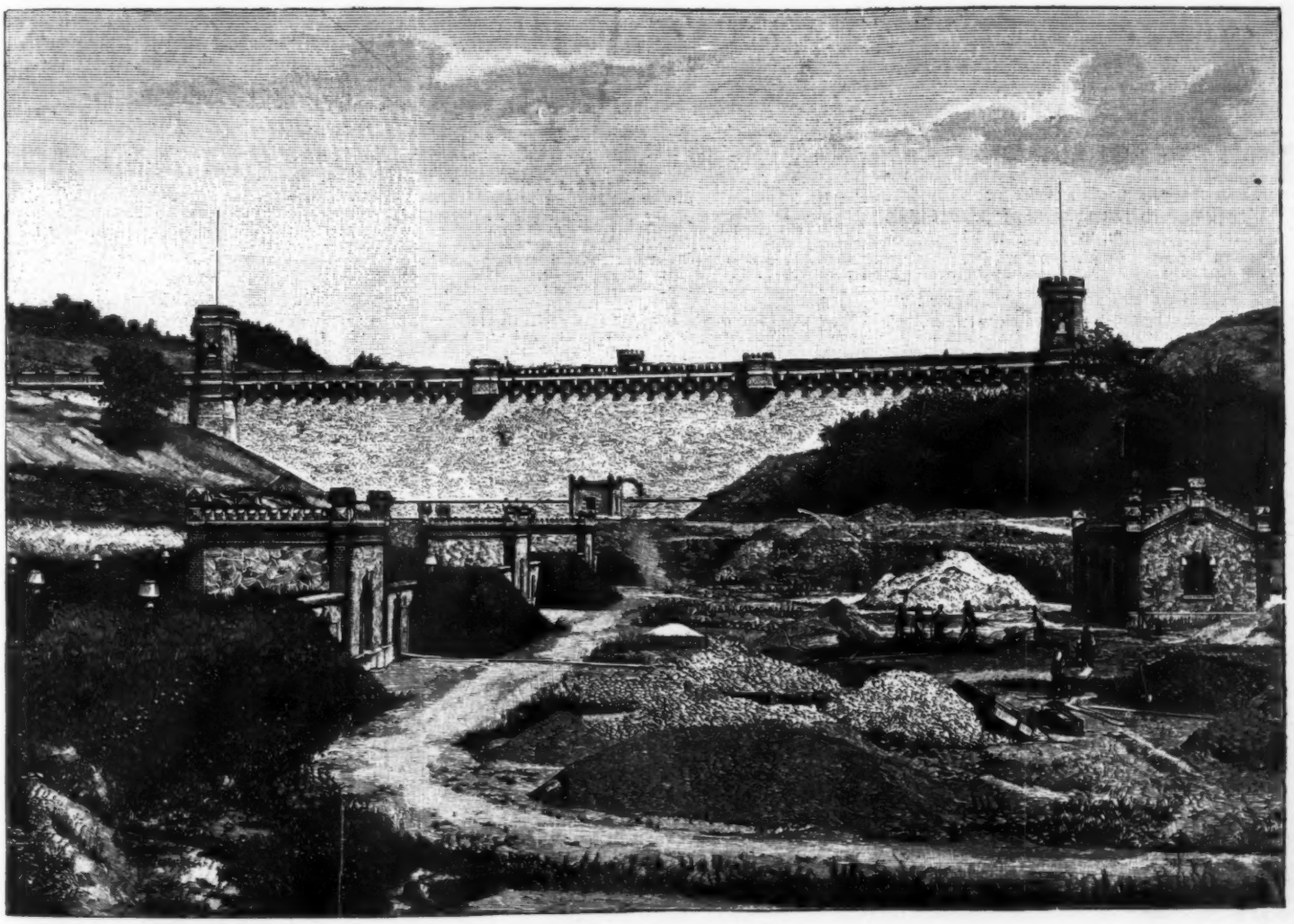
Tests of cement, made without any regard to the conditions under which it is to be finally used, may make a very creditable showing as to strength, and yet prove to be a complete failure in the structure.

Boiler plates may stand a test of over 60,000 lb. per square inch and yet fail under a boiler pressure of less than 150 lb.

One of the most fruitful sources of engineering failure has been due to accepting, without regard to modifying conditions, the results of experiments made to determine the relation between the rate of flow of a river current and the size of the particles which different velocities of current will move. Years ago the French engineer, Dubuat, found that water flowing at the rate of three inches per second would move potter's clay; at the rate of 7½ inches would move coarse sand; at the rate of one foot would move small gravel, and at the rate of two feet per second would be capable of moving round pebbles an inch in diameter. It would be difficult to find a reference book on river hydraulics published since Dubuat's observations were made that does not quote his results as authentic. Col. Elliott in his report on the improvement of Nantucket Harbor assumes that a velocity of 1·25 ft. per second is sufficient to produce a scour on a bottom of sand and gravel, and quotes the following authorities: Debouve, 0·5 to 1 ft. per second; Login, 0·67 to 1 ft. per second; and Weisbach, 1·25 ft. per second.

Trautwine says that, "Scouring action is supposed to be as the square of the velocity of current," and gives examples nearly the same as the above. These authorities are all of such high character that the unsuspecting engineer might accept their results without question, and yet all are absolutely incorrect, except for the particular streams where the experiments were made.

A board of distinguished army engineers, basing their opinion on results similar to the above, recently designed plans for the improvement of an important coast harbor on which several million dollars were to be expended, and in their report say that since the



THE NEW DAM FOR THE CHEMNITZ WATER WORKS.

mean velocity of current across the bar will be 2·7 ft. per second, and the maximum velocity 5·4 ft. per second, such velocities through jetties on fine sand would endanger their stability.

The absurdity of such fear is manifest when we consider that such velocities will not disturb the bottom, in mid-channel, in depth of over 18 ft., unless aided by wave action.

The amount of work that any stream is capable of doing is equal to its volume of discharge into its fall in a unit of time, and since the velocity of river currents varies rapidly with the depth, it is evident that the slope of large deep rivers must be very small, compared with shallow streams having the same velocity, and consequently the scouring action of any river, for any given rate of current, must be an inverse function of the depth. This being the case, to assume that any given velocity will produce certain results is equivalent to trying to solve a problem having two unknown quantities with a single equation of condition.

The action of river currents of different velocities and depths on the channel bed is very cleverly illustrated by the annual changes which occur in the bed of the Mississippi River, where the crests of the bars are raised during the high water and rapid currents of floods, and cut away during the low water stages when the depths are small and the slopes steep on the shallow channels connecting the deeper pools.

The fact that some engineer has found that a given velocity of current on some stream of unknown depth will move sand or gravel has no bearing whatever on what may be expected of currents of the same velocity in streams of greater depths.

In channels 3 to 5 ft. deep a mean velocity of 3 to 5 ft. per second may produce rapid scouring, while in depths of 18 ft. and upward current velocities of 6 to 8 ft. per second often have no effect whatever on the channel bed.

The amount of sediment that a stream, flowing with a given velocity, can carry in suspension has been a subject of bitter controversy among hydraulic engineers, and is by no means a matter on which they are mutually agreed at the present time. Humphreys and Abbot, in their extensive investigation, from 1850 to 1861, to determine the physics and hydraulics of the Mississippi River, conclude that no definite relation exists between velocity of flow and the amount of sediment held in suspension. Their failure to establish such a relation was largely due to the fact that their entire investigation was devoted to trying to determine the relative amount of sediment per cubic foot of water, at different velocities of current, without regard to depth of water, while the fact of the matter is that the amount of material and the size and weight of the particle which a stream can hold up and carry forward is a direct function of the current velocity, and an inverse function of the depth.

Motion cannot occur in matter without an expenditure of force. The transportation of sedimentary matter by rivers can, therefore, only result from an expenditure of force, which must necessarily increase with the height through which the material is lifted, or with the increase in depth of stream.

Many reference books on hydraulics give tables for computing the mean and bottom velocities of streams when the surface velocities are known. Under ordinary conditions these tables may give approximately correct results, yet there are many cases where such methods are certain to give erroneous results. For instance, at the mouth of the Mississippi River the depth on the bars at the mouth of the passes is from 8 to 12 ft., while at a distance of 18 miles up stream the river is over 100 ft. deep, giving an average minus bottom slope up stream of 5 ft. per mile. Salt water being 3 per cent. heavier than river water, flows down this slope (up stream) during low stages of the river at the same time that the surface water is flowing seaward, at the rate of one to one and one-half miles per hour. During seasons of extreme low water the river water sometimes becomes brackish from this cause for over 100 miles from its mouth.

Another hydraulic problem over which engineers have always agreed to disagree is whether the confining of a sedimentary river within its banks by means of levees has a tendency to raise the river bed. A recent writer on this subject says: "Theoretically, and even without any reference to experience, it should be seen that building dikes along the shores of frequently swollen rivers must result in raising the bed over which the water flows." Is this true? In fact, does not the equalization of the river forces and the resistances overcome make such a result an impossibility? If by any means the slope of a river could be increased for any given stage of water, there can be no question but that the flow would be increased, and consequently the capacity to produce scour correspondingly so. All rivers flowing into the sea have the level of the water surface at their mouths fixed by the sea level; consequently any raising of the river bed in the upper portions of the river must proportionally increase the slope between that point and the mouth. But, as we have seen above, increased slope means an increase of the force acting to erode the bottom, and therefore, to assume that levees have a tendency to raise the beds of rivers, forces us to the anomalous conclusion that an increasing scouring force produces a decreasing effect.

There is no doubt but that the beds of sediment-bearing streams do rise, whether the banks have levees or not, but there is no evidence that the building of dikes has in any case ever increased such action.

If we take the Mississippi River, for example, it will be noticed that the slope at Cairo is about six inches per mile, and gradually diminishes to one inch at the mouth of the river. The slope in the Passes is about double that of the main river directly above, showing that any change of depth and volume of discharge requires a corresponding change of slope. The average advance of the Mississippi River delta into the Gulf, previous to the improvement of the South Pass, was about four miles per century, and as the average slope from Cairo to the Gulf is about four inches per mile, it is evident that a silting up of the river bed of over one foot must have occurred during such period in order to maintain the natural slope. In other words, the increasing length of the river, due to the advance of the delta into the Gulf, is the only apparent permanent cause for any rising of the river bed.

This is equally true of the Po and the Yellow River, so often mentioned as examples of the disastrous effects of the rising of river beds, the only difference being that these rivers, having greater slopes than the Mississippi River, have a greater rise of bed in proportion to delta advance.

One great source of error in the results of observations and experiments often arises from an undue belief on the part of the engineer in the infallibility of his work and conclusions.

It is fair to presume that every engineer in undertaking to determine the law governing some phenomenon of nature does his best to arrive at a correct conclusion, but if he fails to take cognizance of all the varying conditions that may exist, his results will probably be very misleading when considered under other circumstances than those existing at the time his observations were made.

Reports and treatises on engineering works contain many examples of this character which the young engineer will do well to scrutinize closely before accepting as basis for designs for work where the conditions are not known to be identical with those on which previous conclusions and reports have been based.

Detroit, Feb. 1, 1894. GEO. Y. WISNER.

ANSWERS TO QUESTIONS ASKED CANDIDATES FOR MINE FOREMEN'S CERTIFICATES.

AT EXAMINATIONS IN THE 4TH, 6TH, 8TH, AND 10TH BITUMINOUS DISTRICTS, HELD JANUARY 16 TO 20, INCLUSIVE, 1894.

Ques. 1.—A mine has four splits, and the quantity of air in each split is as follows: 6 000, 7,050, 7,800, 9,750 cubic feet respectively. State how many persons can be legally employed in each split; and if the airways are 7 × 5 feet, what will be the velocity of each current?

Ans.—By the Act Relating to the Bituminous Coal Mines of Pennsylvania, Article IV., Section 1, if no gas has been seen, then the greatest number of persons that could be employed in the district of each split would be 60, 70, 78, and 97; and if fire damp has been detected, then the number of persons employed in the districts of each of the ventilating currents must not be more than 40, 47, 52, and 65 respectively, and after the 13th of May, 1894, not more than 65 persons shall be employed in the same air current, unless a special allowance of more is granted by the mine inspector.

The velocity of each current is as follows: 171⅜, 201⅝, 222½, and 278⅛ respectively, per minute.

Ques. 2.—What is creep? What causes it? Why is it that creeps occur in some mines and not in others, where the conditions of roof, floor, and coal seam are all equal?

Ans.—A creep is a coming together of the roof and floor in a coal seam. It is caused by the pillars of coal being thrust into the soft floor, or soft roof of the seam, as the result of the pillars being too small, or the mode of working being imperfect.

General creeps only occur in mines where the necessary support of the roof has not been provided for by leaving the supporting blocks of coal large enough, and they do not occur where the mode of working is a correct one.

Local creeps cannot be prevented in any mine between parallel faults, where the roof is broken with great cracks, or where the last pieces of a pillar are being removed.

Ques. 3.—In opening up a mine you come in contact with a fault, and the roof in your entries breaks in all directions from it, what, in your opinion, would be the cause, and how would you proceed to cut through it with safety?

Ans.—The cause of the breaking of the roof must be sought for in the nature of the fault. If it is of that variety called a "dirt fault," then the cause of the breaking of the roof will be found in the pressure of the gas, produced by the stringers of coal in the fault, and to timber or arch through the fault, the pressure of the gas in the roof must be relieved by boring vertical holes every 10 or 12 feet in linear advance.

Ques. 4.—If the velocity of an air current is 4 feet per second, and it had to be increased to 8 feet per second, what would be the increase in the ventilating power?

Ans.—In the latter case the velocity of the air current is doubled, therefore, as the pressures vary as the squares of the velocities, and the powers vary as the cubes of the velocities, in this case the increase in the ventilating power would be from 1 to 8 or as the cube of 1 to the cube of 2

Ques. 5.—What method of ventilation lessens the danger of an explosion and reduces the friction, and state your reason for the same?

Ans.—Ventilation by splitting secures fresh air for each district and prevents the accumulation of inflammable gases, by removing them at once, and thus preventing the possibility of explosions.

Splitting reduces the velocities of the district currents, and at a greater rate reduces the friction, so much so, indeed, that if the rubbing surface remains unaltered, with the same ventilating pressure and half the velocity, twice the quantity of air can be passed through four splits airways that would pass through one of the same section.

Ques. 6.—In what proportion does friction increase and decrease relative to the flow of air through the mine passages? Illustrate by examples. And by what means are the densities of air increased or diminished?

Ans.—The friction due to the flow of air through the mine passages increases directly as the rubbing surfaces increase, extend or lengthen; that is, if the rubbing surface is doubled, or the length of an airway is doubled, then the friction is doubled. The friction due to the flow of air through the passages of a mine varies as the squares of the velocities of the currents; that is, if you double the velocity, the friction is increased four times, or if you half the velocity, the friction is reduced to one-quarter. For example, if the length of an airway is trebled, and the velocity is doubled, then the friction will be increased twelve times, as follows: Let l equal the length directly, and v equal the velocity, then v^2 multiplied by l as $l\,v^2 = p$ or $3 \times 2 \times 2 = 12$, that is, the friction has increased from 1 to 12, and if the length was reduced to one-third, and the velocity was reduced to one-half, the friction would be as $\frac{1}{3} \times \frac{v}{2} \times \frac{v}{2} = p$, or $\frac{1}{3} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{12}$, that is to say, the friction would be reduced from 1 to $\frac{1}{12}$, or from 12 to 1. Increased pressure, or increased cold, increases the density of air; for example, compressed air increases in weight, and heated air reduces in weight, being rarefied.

Ques. 7.—If the airways of a mine were increased to double their length, other conditions remaining the same, in what proportion would you have to increase the ventilating pressure?

Ans.—If the airways of a mine were increased to double their length, the ventilating pressure would have to be doubled, because the pressure must always be equal to the resistance, and in this case the friction would be doubled.

Ques. 8.—If your rooms are turned at an angle of 65 degrees from your heading, how far apart must they be to allow you 6 yards of room and 5 yards of pillar?

Ans.—By the following figure drawn to scale, the

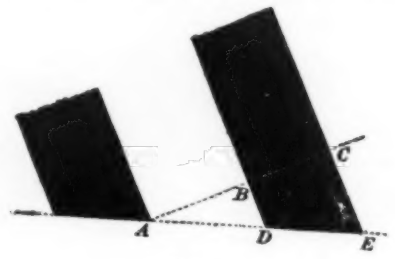


FIG. 1.

distance between the rooms from center to center is 12·14 yards along the side of the heading, and the rooms and pillars along the side of the heading measure 6·62 yards and 5·52 yards.

NOTE.—The distances along the side of the heading can be found by trigonometry by multiplying the secant of 25° by 11, but the scale measurement is quite sufficient.

Ques. 9.—Explain the principle of the steam force pump, and describe the various methods employed to drain water from the dip workings of a mine.

Ans.—The steam force pumps for delivering mine water at the surface are of two varieties; first, where the plungers are worked by a rotary steam engine, and second, where the steam piston and the pump plungers are connected directly. In this engine the slide valve of the steam cylinder is worked by tappets, and the intake and delivery valves of the pumps are of the double beat variety.

The methods of draining the dip workings of mines in so far as the pumps are concerned, may be classed under two heads; that is, plunger pumps and double acting piston pumps, and the power for working these pumps is transmitted by four different agencies, as follows: first, by endless ropes or haulage ropes; second, by compressed air; third, by water pressure; fourth, by electricity.

Ques. 10.—Explain the principle of the siphon. How will the following conditions affect the siphon? First, when the discharge end is short, and the fall rapid, and the inlet end long and the elevation slight, second, when the discharge end is long, and the fall slight with the inlet short?

Ans.—The siphon depends for its principle of action on the pressure of the atmosphere. The siphon would not, therefore, act in a vacuum, and in a pressure of two atmospheres it would act up to twice the altitude of the ordinary siphon.

In the first case, when the inlet is long, and the delivery short, the inlet will drag, and as the elevation is slight the siphon will probably run slow, but the speed and the useful effect of this siphon cannot be determined, because the length of the motive column is not given. In the second case the siphon will run probably faster than in the first case, because there is no drag on the inlet, but nothing can be said with any approach to accuracy, because the altitude and the motive column are not given.

Ques. 11.—Explain fully the principles involved in natural and artificial ventilation, and explain how you would ascertain the entire weight of air in the upcast shaft.

Ans.—One principle is common to natural and artificial ventilation, and that is, there must be a motive column. In natural ventilation, however, the motive column varies, if it depends on the varying temperature of the air, and is uniform if the ventilation is produced by a waterfall. In winter, when the temperature of the rocks forming the roof, sides, and floor of the mine are at a higher temperature than the air at the surface, then the mine is ventilated, or a motive column is produced by the natural heat of the mine. (See Fig. 2.) Fig. 3 shows how the mine is ventilated in summer by the rocks cooling the downcast column and increasing its weight. Where there is a considerable feeder of water in a shaft, and the working seam is above the drainage level of the district, a

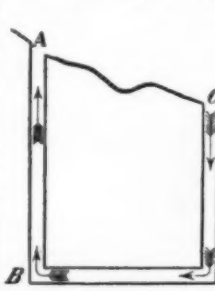


FIG. 2.

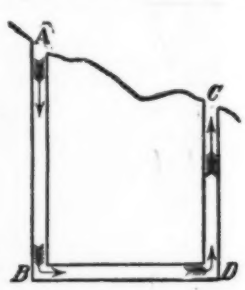


FIG. 3.

considerable and often a constant motive column is obtained from the waterfall. The motive column in artificial ventilation is produced in three distinct ways:

First, by rarefaction in furnace ventilation, when it may be said that a difference in pressure is the result of a difference in weight in the ventilation columns.

Second, by exhaustion, as in fan ventilation, when it may be said that a difference in pressure in the ventilating columns is the result of a difference in the total pressure in the downcast and upcast columns.

Third, by pressure fan ventilation, when it may be said that a difference in pressure in the ventilating columns is the result of blowing, or slightly compressing the downcast column to such a pressure above the return column as will supply the current pressure or force required.

To find the entire weight of air in the upcast shaft, first find the weight of one cubic foot and let the mean barometer read 30·4 inches, and the temperature 70° F.,

$$\text{then } \frac{1{\cdot}3253}{(459+70)} \times 30{\cdot}4 = \frac{1{\cdot}3253 \times 30{\cdot}4}{529} = 0{\cdot}07616$$

nearly.

Let the diameter of the upcast shaft be 12 feet, and the depth 360 feet, then $12 \times 12 \times 0{\cdot}7854 \times 360 \times 0{\cdot}07616 = 3100{\cdot}864$ nearly; that is, the air in this case weighs 3100·864 pounds or about 1½ tons.

Ques. 12.—How would you lay out a system of room and pillar working, with a view to the recovery of the pillars under the various conditions of roof and bottom, the depth of strata and texture of coal seam?

Ans.—In a bituminous seam four feet thick, with a strong sandstone roof, and a thick, soft fire-clay bottom, room and pillar would certainly be the best mode of working. The rooms should not be more than 5 yards wide, and the headings not more than 3 yards wide, and if the depth of the strata is 640 feet, the side dimension may be found as follows: Extract the square root of twice the depth in feet for a soft bottom, when the square pillars should be $\sqrt{2 \times 640} = 36$ yards side measure, or instead of being 36 × 36, the pillars could be 40 × 32 yards. If the bottom and roof were both hard, and the seam strong, and of the same thickness and supporting the same depth of strata, then the dimension of the side of a square pillar should be $\sqrt{640} = 25$ yards on the side, or if the pillar be oblong, it should be 22 × 30 yards. Should the dimensions of the cover, thickness, etc., remain the same, and roof of the seam be found to be a broken soft shale, then the long wall mode of working would be preferable.

Ques. 13.—Show by a sketch the system of ventilation which in your opinion would produce the best distribution of air in a mine, so as to do away with air doors as far as possible, in order to secure the best sanitary results, and the most economical working of the mine.

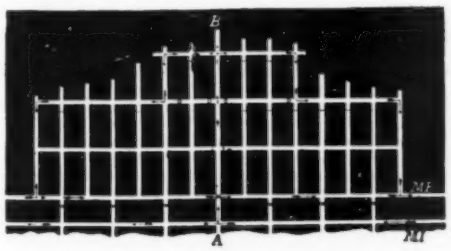


FIG. 4.

Ans.—The figure here given is a ventilated plan of room and pillar, and it will be seen that the ventilation is of the most advanced character for securing safety from accumulations of marsh gas, healthful good air for the workmen and economy in the ventilation of the mine. It will be seen that the main intake air current, MI, is split into the district as shown at A, when it is again split at the top of the panel as at B, and the main return airway from other districts is shown at MR.

Ques. 14.—What are the principal points to be kept in view in the construction of underground hauling roads, so as to insure an economical operation of a mine; and if it were necessary to have a ditch along the heading, on which side would you place this ditch?

Ans.—The principal points to be kept in view are: First, the road must be as straight as possible, and all elevations must be lowered and all depressions must be raised. Second, when curves are necessary on a rope haulage, the rail on the inside of the curve must be raised and the radius of the curve must be as large as possible. Third, the making-up and delivery stations should be sufficiently large to keep the hauling engines running full time. Fourth, the rails should be fish plated, and where the floor is wet and soft, stout battens should lie on the sleepers to support flat bottomed rails. The ditch should be on the low or rear side of the heading, out of the way of the junctions of the branch roads, and on ordinary haulage roads where curves occur, the ditch should in all cases be on the outside of the curve, otherwise the water overflows the road and loosens the sleepers, and causes the frequent derailing of the cars.

Ques. 15.—What is required by law to be kept at a mine to be used in case of accident, and what is the first duty of a mine foreman in case of a fatal or serious accident to an employe?

Ans.—The Act relating to the Bituminous Coal Mines of Pennsylvania provides, Article 18, Section 1: "It shall be the duty of operators or superintendents to keep at the mouth of the drift, shaft or slope, or at such other place about the mine as shall be designated, a stretcher properly constructed and a woolen and a waterproof blanket in good condition for use in carrying away any person who may be injured at the mine. Provided, that where more than two hundred persons are employed, two stretchers and two woolen and waterproof blankets shall be kept. And in mines generating fire damp a sufficient quantity of linseed or olive oil, bandages and linen, shall be kept in store at the mines for use in emergencies, and bandages shall be kept at all mines."

The first duty of a mine foreman after a serious accident is to report the same to the inspector of the district, and if the case is fatal, to the coroner also of the county. Article 12, Sec. 1.

Ques. 16.—How would you set a prop in a mine under the following conditions?

A. With a soft bottom and a hard top?

B. With a hard bottom and a soft top?

C. Where the seam is pitching at an angle of 10 degrees?

D. How would you set the timber to support the roof and sides?

E. What are the smallest size props, in your opinion, that should be used in a coal mine and of what kind of wood?

Ans.—A. With a soft bottom and a hard top, the feet of the legs should be set on foot laggings or foot stringers running lengthwise with the road.

B. With a soft top and a hard bottom, if the top was very soft, I would set the heads of the legs under collars supporting cross laggings.

C. Where the seam is pitching at an angle of 10 degrees, the legs should be set at 90° with the roof and floor of the seam, or in this case 10 degrees out of plumb, or the heads of the legs should lean down the slope 10 degrees out of a vertical line.

D. The ends of the head tree or collar should be notched, and the feet of the legs set into the hard bottom stone. When, however, the top and sides are very soft, they should be secured with close lagging, and in bad cases the timber sets should be set nearly close.

E. The smallest size for mine timbers, that is the legs, should be 3 inches in diameter, and the sizes for thicker seams can be found as follows. Extract the square root of 9, multiplied by the thickness of the seam in feet, the result is the diameters in inches. Example, what should be the diameter of legs for a 6 foot seam, $\sqrt{9 \times 6} = 7{\cdot}3$, practically 7½ inches.

The best kind of timber in use for mine legs, collars and lagging is hemlock.

Ques. 17.—Explain fully the principle of an exhaust fan, and also the principle of a force fan, in producing ventilation in a mine.

Ans.—The exhaust fan, as its name indicates, reduces the pressure of the air in the fan drift below that of the external air, its action being that of a centrifugal pump. The amount of exhaustion or approximate vacuum required is equal to the resistance of the ventilating current of the mine. The force fan is somewhat opposite in its mode of action to the exhaust fan, which inhales and exhales the mine air, whereas the force fan inhales and blows into the mine the fresh air. The pressure of the force fan must be equal to the friction of the ventilating current, and in this respect the two varieties of the mechanical ventilators are alike, but a high percentage of useful effect is lost, by the exhaust fan blowing out the return air at a pressure above the atmosphere, equal to the pressure below the atmosphere, in the fan passage.

Ques. 18.—If your ventilation were inefficient, and you could not increase the power, how would you increase the ventilation, and what are the inexplosive gases met with in coal mines?

Ans.—There is only one way open to increase the ventilation without increasing the power, and that is by reducing the resistance in the path of the air current.

The resistance can be reduced in two ways: First by reducing the rubbing surface per square foot of section, and second by reducing the velocity.

If the airways are made larger in section, the rubbing surface and the velocity are both reduced. Again, the velocity can be reduced by splitting the principal currents into two or more streams of air, when an increased ventilation can be obtained without increasing the ventilating power.

The inexplosive gases found in mines are carbonic acid gas and one of the gases in the air, namely, nitrogen. Oxygen is one of the principal agents in explosive mixtures.

GAS QUESTIONS.

Ques. 1.—Describe the structure of the safety lamp, and state upon what principle its safety depends. What lamps are condemned by law?

Ans.—The structure of the best safety lamps may be considered from five different points of view. First, the bottom or the body of the lamp, or the oil vessel in which is found the tube for supporting the wick, and in connection with which is the adjusting pricker to correct the light. Second, the frame and rods to support the glass and gauze cylinders, and to which are attached the tile and hand ring. Third, the glass cylinder to screen the flame from the outside air, and to allow for the free passage of light. Fourth, the gauze cylinder to prevent the outward passage of flame. Fifth, the bonnet, or metallic shield, or cover to prevent the passage of flame out of the lamp, by strong currents of wind.

The principle on which the safety of the safety lamp depends is the power of the gauze cylinder to prevent the passage of flame by chilling it. As flame is only white hot gas, and when the temperature of the gas falls below a white heat, it ceases to be flame, it therefore cannot ignite other inflammable gases. As flame can be passed at a high velocity through the meshes of wire gauze, such a high velocity is prevented by the use of the metallic shield. The Bituminous Mine Law, Article 5, Section 6 forbids the use of the common Davy lamp and Clanny lamps without shields, excepting by the mine officials for testing for gas.

Ques. 2.—What is the first duty of a fire boss on entering a mine?

Ans.—Bituminous Mine Act, Pennsylvania, Article 20, General Rule 9. Duties of fire boss. "He shall enter the mine before the men have entered it, and before proceeding to examine the same, he shall see that the air current is traveling in its proper course, and if all seems right, he shall proceed to examine the workings."

Ques. 3.—Describe the instruments that are most useful in aiding the fire boss, in determining the condition of the mine.

Ans.—The fire boss must have access to a barometer and a thermometer to inform his judgment, and he should carry with him an anemometer or wind meter, and by law a safety lamp.

Ques. 4.—What are the explosive gases found in coal mines? Describe their properties, composition, specific gravity; how and where are they produced in mines, and under what conditions do they become explosive?

Ans.—There are two explosive gases found in coal mines; namely, marsh gas and sulphureted hydrogen. Marsh gas has no color or smell, is very inflammable and very explosive when mixed with certain proportions of air, such as one of the gas mixed with nine and a half parts of air. Its composition is $C H_4$ or one volume of carbon combined with four volumes of hydrogen; and air having a weight of 1, marsh gas is 0·55; that is, it is little more than half the weight of air. Sulphureted hydrogen stinks and smells like rotten eggs; it has no color; it is very inflammable and explosive, and has a low point of ignition; its composition is $H_2 S$, or two volumes of hydrogen combined with one of sulphur, its specific gravity is 1·179, air being taken at one, it is thus a little heavier than air.

The marsh gas is given off by the coal, being the result of slow chemical change; and sulphureted hydrogen is the result of the chemical action set up by acidulated water acting on the coal, and is therefore found most abundant in old workings flooded with water, or is given off by the water that is met with in the neighborhood of faults.

Large volumes of fire damp in holes in the roof or in goaves, when disturbed by mechanical action, such as a blow out or false shot, or by the expansion that takes place when the barometer falls, are common causes of this gas mixing with air and becoming explosive. Sulphureted hydrogen is more to be feared for its power to transmit flame, and thus to ignite explosive mixtures of fire damp.

Ques. 5.—How would you proceed to look for and detect explosive gases in mines?

Ans.—For detecting fire damp, after having reached a point in the workings where the gas may collect, I would lower the light of my safety lamp with the pricker, and then slowly raise the lamp with one hand and screen the light from my eyes with the other, to see the characteristic blue cap of fire damp on the flame, which can only be seen in a very subdued light. Sulphureted hydrogen can be detected in small quantities by its smell.

Ques. 6.—In what stage of mining operations does the gr atest number of accidents occur from explosions of fire damp?

Ans.—In deep seams when the first headings and entries are driven into the coal on opening out new mines, much fire damp is met with, and explosions frequently occur. Old mines are subject to explosions, as the result of accumulations of fire damp in the goaves, so that explosions of fire damp characterize new and old mines, mines of middle age being less subject to accidents of that kind. The period of the day when explosions are most frequent depends on the practices of the district in relation to shot firing.

Ques. 7.—Should any workmen receive injuries from an explosion of gas, what would you do for them until the arrival of a physician?

Ans.—Besmear the burnt portions of their bodies with linseed oil and screen them from the air with linen bandages until the physician arrives.

Ques. 8.—How does the fall of the barometer affect the flow of gas from falls in the mines?

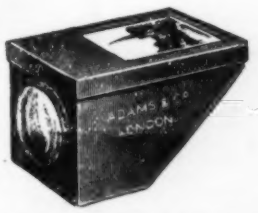
Ans.—Air in common with other gases expands and contracts in the order of the operation of Boyle and Mariotte's law, hence as the pressure of air reduces, the volume increases. The barometer, as its name indicates, is an instrument for measuring the weight or pressure of the atmosphere; consequently, as the barometer falls, the volume of the air and gas in the goaves, passages, broken roof, and fissures of the mine expands; and by this means we find the cause of gas or fire damp fouling the ventilating currents during the period of the falling of the barometer.

Ques. 9.—What are the lawful duties of a fire boss?

Ans.—The lawful duties of a fire boss are set forth in the Bituminous Coal Mines Act, Pennsylvania, Article 5, Sec. 2, as follows: "In all mines wherein explosive gas has been generated within the period of six months next preceding the passage of this act, and also in all mines where fire damp shall be generated, after the passage of this act, in sufficient quantities to be detected with the ordinary safety lamp, every working place without exception and all roadways shall be carefully examined immediately before each shift by a competent person or persons appointed by the superintendent and mine foreman for that purpose. The person or persons making such examination shall have received a fire boss' certificate of competency required by this act."

A DOUBLE REFRACTING FINDER.

NOT double refracting in the sense understood in the polarization of light, but rather a finder having two refracting lenses. This finder is different in its optical construction from any other. There is no ground glass about it. An image is formed by a convex lens, and this is directed at a right angle by a mirror, covered by another and somewhat powerful convex lens, which forms an eyepiece. The result of this arrangement gives a finder having an exceeding degree of luminosity. In fact, it need not be shaded from the direct beams of the sun at all. Some idea of its exterior may be had from the cut.—British Jour.



A DOUBLE REFRACTING FINDER.

THE WORK OF SCULPTORS.

BEFORE executing a statue in marble, the artist makes a model in clay or plaster to serve as a guide for shaping the stone.

The material work of rough carving is not done by the sculptor himself, but is confided to a specialist, who so shapes the marble as to give it the general outlines of the figure to be reproduced. To this effect he drills a series of holes in the block, the depth of each of which corresponds to an external point of the statue supposed to be inclosed in the stone. After a sufficient number of these holes have been made, he removes the entire perforated portion, and what remains gives the broad lines of the statue.

The focusing can be effected simply by means of a series of vertical cords and the compasses or of a special instrument called the sculptor's cross.

The first process consists in suspending from a rectangular frame, c c, a series of plumb lines around the model and an exactly similar series around the marble to be chiseled. These lines are marked with

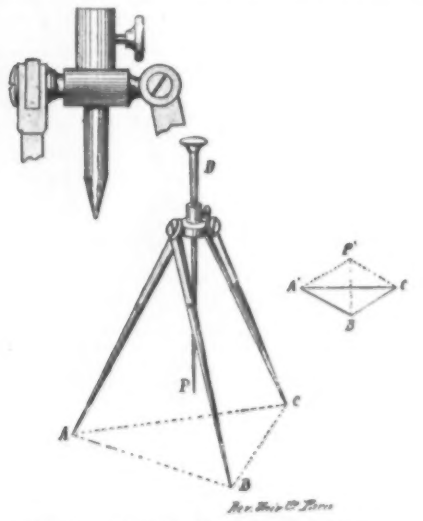


FIG. 1.—SCULPTOR'S COMPASSES.

divisions starting from the frame. In order to mark a datum point of the statue in the marble, the workman measures upon one of the cords its vertical distance, h, from the plane of the frame, c, and then, by means of the compasses, its horizontal distance, d, from the cord. This done, he places the drill near the corresponding cord of the block at the distance, h, beneath the frame. He has previously taken care to mark the length, d, upon the drill, starting from the point, and he then bores the hole until this mark comes flush with the cord. The extremity of the hole is then at the distance, d, from the cord.

In operating in the same way for a series of datum points marked off upon the model, the workman finally succeeds in imprisoning the general form of the statue in a multitude of facets which, through their reunion, give the general form of it. Let us remark that the only thing done here is to determine a point of space by its distances from three rectangular axes.

The Sculptor's Cross.—The process just described is advantageously replaced by an instrument called the sculptor's cross, which is based upon the principle that a point is determined by position in space when we know its distance from three fixed points.

This apparatus (Fig. 3) consists of two iron rods at right angles with each other and connected by a double socket, H, analogous to that of a marking gauge. The rod, D, is provided at the top with a bent point, C,

FIG. 2.—METHOD OF FIXING THE OUTLINES OF A STATUE.

and the other one with two straight points, A and B. The extremities of these three points, A B and C, constitute the fixed points, with respect to which the positions of the different parts of the model are determined.

Upon the rod, T, slides a socket, E, which, through a ball joint, K, supports the bar upon which the exploring style, S, is placed.

The operation is as follows: The workman selects three points, A B C, upon the model and three corresponding ones upon the block. The points of the apparatus are fixed once for all, so as to apply themselves exactly, either upon the model or upon the block, to the three points in question.

Having fixed the intermediate style-bar in a proper position, one of the points of the model is put in contact with the style, S; the screws of all the joints are tightened, and then the instrument is transferred to the block. The latter is then chiseled away until a region is reached upon which the point, S, can rest, the three points, A B C, being placed at the fixed points of the block. The same thing is done for a series of points quite near each other and arranged over the whole surface of the model. The mobility of the sockets, D D, and of the ball joints (see details to right of figure, that of the ball and that of the style-carrier) permits of reaching all the regions of the statue without changing the position of the points, A B C; and this assures great accuracy in the work as a whole.

Finally, the contours of the figure are determined point by point.

For statuettes, the workman uses compasses with three legs (Fig. 1), the function and method of using which are absolutely the same as that of the cross. The three points, A B C, of the compasses correspond to the fixed points of the figure. The point, P, movable in a socket, in which it can be fixed with a set screw, serves as an explorer. Here the points, A B C, are not absolutely fixed; three corresponding points having been selected upon the model and the block, a fourth is determined with the point, P. In starting from the point thus obtained and from two of the points previously fixed, a fifth is found, and so on. Certain improved compasses permit of keeping the points, A B C, in the same position, and this is evidently much preferable.—Revue Universelle.

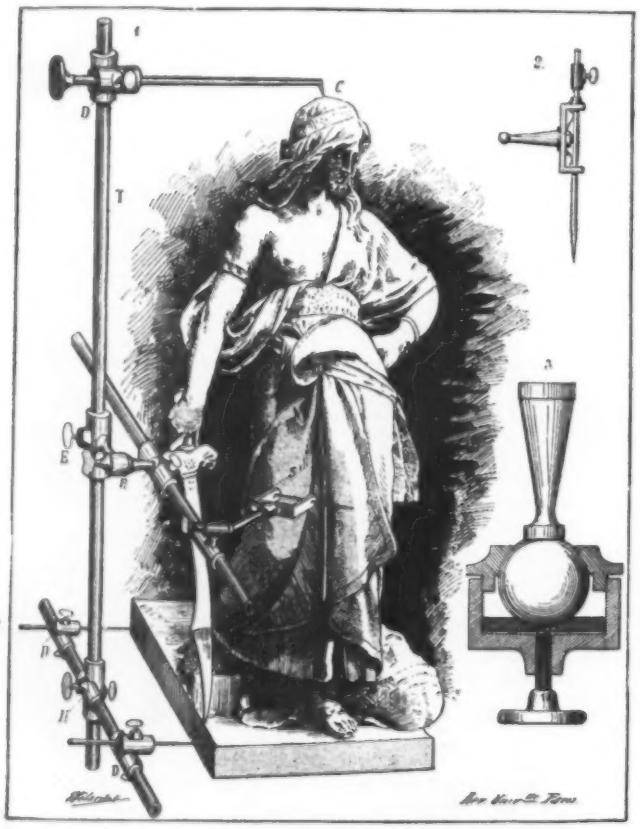


FIG. 3.—THE SCULPTOR'S CROSS.

DRAWING OFFICE RULES.*

By A. W. ROBINSON, Milwaukee.

SHOP Drawings.—1. All drawings shall be of the uniform size of 23 in. by 36 in.

2. All detail drawings for use in the shop shall consist of whole standard sheets, half standard sheets, and sketch sheets. Half sheets shall be 18 in. by 23 in., formed by ruling a line across the center of standard size sheets as filed, the blue prints only to be cut, and mounted and varnished when necessary.

3. The sketch sheets shall be 8 in. by 11 in., and shall be used for all simple details, forgings, for bolt lists, and for all temporary work capable of being shown in this way. All standard machines shall be fully drawn out and blue printed. The sketch sheets shall be made with indelible pencil or copying ink and press copied in the book for the purpose. The information on the sketch sheets shall be as complete as that specified for drawings.

Character of Shop Drawings.—4. A shop drawing is to be considered as an order or instructions to the shop, and not merely as a statement or illustration. For this purpose it must convey clearly all the information needed to make and finish the article.

5. Every dimension necessary to the execution of the work is to be clearly stated by figures on the drawing, so that no measurements need be taken in the shop by scale. All measurements to be given with reference to the base or starting point from which the work should be laid out.

In comparatively simple constructions the several parts are to be shown together complete, although each part must be figured independently and details supplied, if necessary, by sketch sheet. In more complicated forms each part should be detailed by itself and a general drawing made showing the thing complete. No details should be sent out without putting them together on a drawing, or taking them from a general drawing, so as to insure their fitness. Unnecessary duplication of views to be avoided, except in display or advertising drawings.

6. All figured dimensions on drawings to be plain round vertical figures, not less than $\frac{1}{8}$ in. high, and formed by a line of uniform width, and sufficiently heavy to insure printing well. No thin, sloping, or doubtful figures or diagonal-barred fractions will be tolerated. All figured dimensions below 3 ft. to be expressed in inches.

7. All center lines to be alternate dot and dash in fine black line. All dimension lines to be in continuous red lines, with a central space for the figure, and of such strength as to show on blue print more faintly than lines of drawing. Lines of drawing to be bold and clearly defined in proportion to the scale, and to be shade lined by making the right hand and bottom lines heavier. No ornamental shading or other "frills" allowed on shop drawings.

Title.—8. Every drawing, whether whole or half sheet, shall have the title, date, scale, and number of the sheet placed in lower right hand corner. One man will be detailed for this duty, to secure uniformity.

9. The name of the drawing, as given in the title, is invariably to consist of two divisions, in one line, separated by a hyphen. The first division is to state the general name of the thing or machine, and the second division is to clearly designate the part or parts represented (or, if a general view, should so state). The wording of the titles should be submitted to the chief engineer or head draughtsman for approval.

Drawing Symbols.—10. Detail shop drawings should state:

(1) The pattern number of every casting in plain figures of larger size than the dimension figures.

(2) The number of each piece required for one set. This should be written in one word (not figures) and followed by symbol of material.

(3) The material of which the parts so ordered are made, using symbols as follows:

C. I.—Cast iron.
W. I.—Wrought iron.
C. S.—Cast steel.
M. S.—Machinery steel.
Bs.—Brass.
C. R. S.—Cold rolled steel.
H. S.—Hammered steel.
V. F.—Vulcanized fiber.
Bbt.—Babbitt.
Bz.—Bronze.

Other materials write full name.

(4) The kind of finish on each of the different parts will be indicated by a letter preceding the figured dimensions, as follows:

F. means "finish," and indicates that the surfaces to which it applies are to be machined or dressed in suitable manner to size stated.

F. B. means "finished bright," or polished.

G. F. means "grinding finish," and indicates that

* Paper read before the American Society of Mechanical Engineers, Montreal meeting.

the only finish to be allowed is that necessary for grinding.

When no letter precedes the figured dimension it is understood that the part is to be left black or rough. In cases where finish might be presumed, but not required, follow the figured dimension by the word "cast" if a casting, and "rough" if a forging.

(5) A reference list of sketch sheets that may be used for detail illustrations.

Sketch Books.—11. Each draughtsman will be supplied with a sketch book by the company, in which he shall make all his notes, calculations, and data, referring to his work, and under no circumstances shall original work be done on loose sheets and transcribed into these books. No effort should be made at neatness or nicety in these books, but each entry should invariably be commenced with the name of the thing and the date, and full notes made of data on which the calculations were based, and the results obtained clearly stated. These books are to be the property of the company.

Index for Drawings.—12. An index book for drawings will be kept in the drawing office by the clerk. This book will be divided into as many divisions as there are drawers, with provision for indexing 100 drawings in each drawer. The names of the drawings will be added to the various divisions according to their classification. The system of numbering shall be as follows:

13. Each drawer shall be numbered consecutively, and shall contain drawings devoted to a certain class of work, which shall be indicated on the drawer label. The drawing number shall consist of two or more digits, with a decimal point between them. The whole number shall indicate the number of the drawer, and the figures after the decimal point shall indicate the serial number of the drawing in that drawer. For example: Drawing No. 5·16 is the 16th sheet in Drawer No. 5, and Drawing No. 75·96 is the 96th sheet in Drawer No. 75. Not more than 99 drawings shall be put in one drawer, save in exceptional cases.

14. Sketch sheets will bear the number of the letter and page of the letter book, preceded by the letter S, to distinguish them from drawings, and will be indexed in their own impression book, but not in the drawing index book. They will be referred to on general drawing of which they are details, and will also bear the number of such drawing.

15 When making a new drawing the draughtsman will apply to the clerk for a number, and will be allotted the first unappropriated number in the division of which the drawing will belong.

16. On completion of every drawing or sketch sheet it must be examined and initialed by the engineer before being issued, and the following entries made in books kept for the purpose:

(A) Record of blue prints and sketch sheets issued to shop, giving date, number, and title.

(B) Drawing Index.—Record in day book the number, title and sub-title, draughtsman, and date.

(C) Pattern Index.—Record in day book the number, classification, and correct name of patterns, with remarks and date.

Each draughtsman will see that these entries are properly made.

Patterns.—17. All patterns shall be numbered with the number of the drawing from which they are first made, followed by a letter indicating its serial on that drawing. For example, if four patterns are shown in detail on drawing No. 36·50, the patterns shall be numbered 36·50A, 36·50B, 35·50C, 36·50D. When existing patterns are utilized in a new design or machine, their original number is to be noted on the drawing on which they are shown in their new employment.

18 Upon receiving formal notice from the pattern shop that patterns are ready for inspection, the draughtsman connected with the order shall examine same and issue foundry order for the casting. The date of inspection and name of inspector shall be entered upon the pattern maker's report at the time of making such inspection.

The sketch sheets referred to in these rules are 8 in. by 11 in. in size. They are of stiff cardboard, and the heading is printed in copying ink. The sketch is made with aniline copying pencil, the "Eagle No. 2" in wood being used. They are press copied in books for the purpose, and several books are used for different classifications of work. The books are of slightly heavier tissue paper than is commonly used for correspondence, and have 500 leaves, each numbered consecutively throughout the series, so that the number of a sketch sheet is never duplicated. In this system there are six books for copying sketch sheets, representing as many classes of work, and these divisions will readily suggest themselves as required for any particular case.

The use of these sketch sheets is especially for work which does not require to be often duplicated, and for giving quick dispatch to emergency work. A free hand sketch can be made, copied, and issued in this way in 10 minutes, while the regular process of drawing, tracing, blue printing, and waiting for the latter to dry, or the sun to shine, may consume hours. They have the additional advantage of being more convenient to handle and file away in the shop than blue prints, and they save multiplication of tracings, and consequent drawer space. The copies being in book form, cannot be lost, and easily indexed and consulted. Sketch sheets are convenient for rapid detailing of forging and small parts, and such parts need, therefore, to be merely indicated on the general or erecting plan, and reference numbers given of the sketch sheets. The sketch sheets will also appear as items in the order list.

In addition to the stiff cardboard sheet, it is convenient to have a "Drawing Office Memorandum" blank. This is a copying ink heading printed on a sheet of letter paper, and is used for order lists, and all sketch matter sent abroad from the drawing office.

After copying, the sketch sheet, if for permanent use, is sized with a mucilage composed of gum tragacanth and water, and then varnished with white shellac and alcohol. The sizing is to keep the lines of the sketch from running while varnishing.

It is our practice not to finish original drawings, but to trace from them on tracing cloth. These tracings are only used to print from, and are filed away in a fireproof vault. Two prints are made of each tracing as soon as finished, one for the shop (or more if necessary) and one to file away in the drawers of the office. These drawers are 24 in. by 38 in. by 2 in., and are each calculated to hold a maximum of 100 prints. In this way the tracings are preserved from risk of fire and loss, and from the wear of frequent handling.

As a rule, each draughtsman makes his own tracings, and only skilled draughtsmen are employed. The writer does not advocate the employment of cheap draughtsmen to trace shop drawings from the originals of the designer. If this is done, the designer must finish his original to entire completeness before turning it over to the tracer, thus consuming additional time and running more risk of errors and omissions than if he traced it himself. A skillful draughtsman will merely block his entire work on the original, and give his whole thought to the perfection of his design. In the tracing he can rearrange his drawing if necessary, and the time occupied in tracing is usually much less than that employed in working out and perfecting the design, and a draughtsman worth $120 per month will usually trace twice as fast as one worth $60, and do it better.

The titles on drawings are mainly done by rubber stamps giving the name of the company, the number of the drawing, and having spaces for the insertion of name, date, and scale.

Some experimenting was done to find a suitable stamp ink for tracing cloth. Printers' ink was tried, but it rubs off and does not dry satisfactorily. A special lithographic ink is used, which is similar to printers' ink, but with addition of a drier. It is applied to the stamp by a composition roller in similar manner to printers' ink, and gives a black impression which blue-prints well. The number stamp has movable type.

As a rule, it pays to employ only high-class labor in the drawing office. A draughtsman puts his own impress on his work, his individuality goes into it, even if closely supervised, and it is upon the perfection of detail that the success or failure of a new design mainly depends; it is important that the draughtsman intrusted with it shall have the necessary skill and ability. We have appliances for testing the efficiency of almost every known mechanism, but who can measure the efficiency of a draughtsman? We appreciate the economic value of good steam distribution and the like, but too often is the efficiency of the draughtsman neglected, and thousands of dollars spent in the construction of work which would have yielded much better results if a little more brains had been used in its design.

In conclusion the writer would say, Do not have so much system that it is difficult to work to or burdensome to carry out. A few simple rules, faithfully adhered to, are better than the most elaborate system which is loosely or imperfectly carried out. The object of a system is to define the duties of each man and to fix the responsibility for dereliction of duty.

A CHEAP PLANIMETER.

THE Amsler planimeter is an apparatus that is so universally known and employed that it is neither necessary to describe it nor point out the principle of it. It permits, as well known, of determining, through a direct reading upon a graduated wheel, the surface limited by a closed contour, such as that of a steam engine or gas motor diagram traced by the classical Watt indicator. But the Amsler planimeter is a relatively costly and complicated apparatus, and the operation that it performs can be effected with rapidity and a nearly equivalent accuracy with a planimeter, which is as simple as it is ingenious, devised by Capt. H. Prytz, of the Danish army.

As its name, stang planimeter, indicates, the apparatus consists of a simple steel rod of which one of the extremities is bent and terminates in a sort of knife, and the other extremity in a blunt point, with the essential condition of construction that the latter shall find itself in the plane defined by the slightly rounded edge of the knife. The point is held in the right hand and describes the contour of the surface to be measured, while the knife is arranged upon the paper in following a trajectory that depends both upon the form of the curve and the initial point of departure. The distance between the extremity of the blunt point and the point of contact of the knife edge upon the paper constitutes the length of the planimeter, which, in the apparatus in our possession, is exactly 25 centimeters. A theory which is quite complex and which we shall not here give, although it brings into play only some classical formulas of trigonometry and integral calculus, establishes that, upon making the point describe the contour of the surface under certain conditions that it remains for us to specify, such surface will be equal to the product of the length of the planimeter by the distance of the two positions of the knife before and after the operation, under reserve of a factor of correction that is rendered null or negligible by construction and by operation. The modus operandi is most simple.

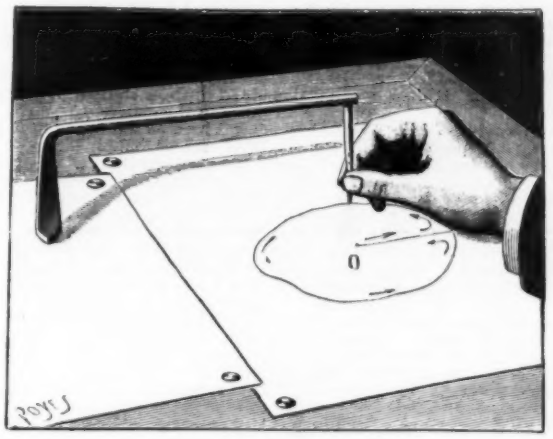
The blunt point of the apparatus is placed near the center of gravity of the surface whose extent it is desired to determine, the knife resting upon the paper, and then one bears upon the knife in order to mark the starting point. Then the point of the planimeter is displaced according to any line whatever traced in advance up to the edge of the figure. After this, the curve limiting the figure is described in one direction or the other, and then one returns to the center of gravity by the same route. One bears upon the knife again in order to mark the point of arrival, and the operation is then finished. The accompanying figure clearly shows the form of the apparatus and the mode of operating, the trajectory of the blunt point being indicated by the arrows.

Upon making the product of the length of the planimeter (distance from the blunt point to the point of tangency of the knife with the plane of the paper) by the distance of the two traces left upon the paper before and after the maneuver, we obtain the surface limited by the curve described. Such surface will be expressed in square centimeters, if the two distances are measured in centimeters. In order to eliminate the error due to ignorance of the exact position of the center of gravity, we may make a second measurement in turning the figure by 180 degrees and repeating the same series of operations.

The mean of the results of the two measurements gives a more approximate value of the surface. The accuracy is so much the greater in proportion as the ratio of the length of the planimeter to the mean radius of the surface is greater. It is well not to exceed half the length of the apparatus for the mean radius. When the surface to be measured is too great to satisfy this condition, it is decomposed into smaller parts, and these different parts are then successively integrated. The error resulting from the relative proportions of the figure to be integrated, and of the length of the apparatus, is found in part compensated for by the fact that we substitute the chord for the arc in the measurement of the distance of the two positions, initial and final, of the knife.

In order to be certain whether the direction of the edge of the knife passes right through the point, it suffices to describe, a great number of times, any straight line whatever, in returning to the starting point. The knife itself ought to be found again at the starting point.

What we have just said shows that it is difficult to conceive of and realize a planimeter of greater simplicity than that of Capt. Prytz.—La Nature.



THE PRYTZ PLANIMETER.

CONCRETE CONSTRUCTION—ITS PRACTICAL APPLICATION.*

By ERNEST L. RANSOME.

THE practical application of concrete may be conveniently divided into four divisions, viz.:

1. False work.
2. Materials.
3. Tools.
4. Labor.

The second division can be usefully divided into four sections, viz.:

A. Cement.
B. Aggregates.
C. Iron.
D. Water.

Division A. False Work.—Concrete in respect to false work is unfortunate in comparison with other masonry, because it not only needs more expensive centering whenever centering is necessary, but it also usually requires cribbing, whereas other masonry does not.

This characteristic entirely prohibits its use in many cases where in all other respects it would be very desirable, and it is, therefore, an obstacle to the more extended use of this valuable construction that should be minimized as much as possible.

Of late years I have met with considerable success by adopting systems of standard centering and cribbing, which, while not of universal application, are of great use, permitting, as they have done, of the construction of floors and buildings that otherwise could not have been attained.

Such false work can be used over and over again many times for a long period without material change or repairs, and the parts ultimately requiring renewing are comparatively inexpensive, but as this is of interest to the contractor rather than to the architect, I will not enter into a detailed description thereof.

Great difficulties have often arisen in the swelling of

* Paper read before the Society of American Architects October 17, 1894, by Ernest L. Ransome, of Chicago, late of San Francisco.

the sheeting of the centering or cribbing, caused by the wood absorbing the moisture of the newly placed concrete. From this cause many arches have been lifted and broken, floors cracked and walls thrust out of line. By using sheeting boards of a moderate width, say six to eight inches, and beveling one edge slightly, the boards may be put close together, and when expansion occurs the only effect will be to slightly crush the outer edge of the bevel without lifting or disturbing the concrete abutting or resting upon it, the widest side of such boards being, of course, placed facing the concrete.

This is such a very inexpensive, simple and unfailing remedy that from its conception I have used it in all cases, and since its use I have never had any trouble from swelling of the timber. Some such device as this is especially necessary in dry climates, also in light construction, such as floors of but an inch or two in thickness or hollow walls.

For standard centering or cribs, if of wood, it is advisable to make them of planed lumber. The surface of the wood should be thoroughly coated with common thick kerosene oil before it is used for the first time, and before each subsequent use it should be brushed over afresh with the oil. Fish oil is objectionable, as it is apt to injure the surface of the concrete, and linseed oil is generally too gummy for this purpose.

It may be accepted as a general rule that false work of light sheeting, well braced, is more economical than heavier planks with braces farther apart. I am aware that this is not the usual practice.

The ornamental effects can be much more cheaply produced by recessed than by projected work.

Materials.—Under this head cement, by reason of its greater cost, and active qualities, stands out pre-eminent. I will limit my remarks under this subdivision to Portland cement, with the exception of the following observation, viz.:

That where rapidity of construction is not a great object and aggregates are unusually cheap, by the use of common lime, with or without some of the cheap native cements, properly handled, work of a good quality and of astonishing cheapness can be made—one part of lime to forty parts of aggregates not being considered too little in some cases.

Portland cement, a giant from its birth, is striding rapidly along the way of improvement and quality and price, so that formulas of tests that were thought severe a few years ago would not be considered sufficiently exacting at the present time to insure as first-class the cement that would successfully pass them.

The current technical literature teems with methods of testing, so that we can hardly go astray in the selection of a good cement. The three principal requisites for a first-class article are as follows:

1. That it sets or hardens without undue expansion or contraction.
2. That it be sufficiently finely ground.
3. That its tensile strength be high.

1. The Cake Test.—This test is so well known that a description of it here is unnecessary. When time is an object, by the use of hot water the test may be hastened. Under expert supervision the boiling test is by many considered superior to the cake test, but the difficulties in the way of carrying it out and some uncertainties in the results that yet linger about this new test prevent me from advocating its substitution for the older test.

2. The Test for Fineness.—Ninety per cent. of the cement should pass through a hundred mesh screen having 10,000 holes to the inch. It would be better to use a yet finer screen for testing, but for the difficulty of readily obtaining finer screens. The practice of using coarser screens is to be condemned, because they pass much that is inert. The screenings should feel soft and silky to the touch. The residue on the screen should be hard, black, angular grains. The economic importance of fine grinding has seldom been exaggerated. It is usually unduly disregarded, yet it has been established beyond reasonable doubt by repeated experiments that the sand-like grains of the cement are practically inert and useless. Still, unlike the first qualification, this is an economic question, and the ill effects of coarse grinding, if not apparent in the first test, can be overcome by making due allowance for the coarse portion in proportioning the cement to the aggregate, and then but little harm will follow the use of coarse ground cement in ordinary work.

3. Tensile Strength.—This test is usually and best made by aid of the ordinary testing machine. Several first class cements will now develop tensile strengths of 600 or 700 pounds per square inch in seven days, and while this may be too high a standard to insist upon, yet the cement that will not furnish a strength of 450 pounds in seven days ought not, in my judgment, to be graded as first class, unless it is exceptionally fine ground. It is desirable, when time will permit, to make the tests with a mixture of one of cement to three of sand, but ordinarily with cements of equal fineness, the relative strength of different brands will remain about the same as under the test with neat cement.

With regard to the aggregates, not so much has been published.

Sufficient interest is not usually taken in these inert materials, which, nevertheless, have a powerful influence upon the character of the concrete, so much so, that a good concrete with a poor cement will sometimes give better results than a good cement with a poor aggregate.

A first class aggregate should be made of a hard, tough rock, free from clay or dirt, and having a rough surface and sharp angles when broken, it should be so graded from the finest grains to the largest pieces admissible in the work it is for as to give, while retaining the largest proportion of large sized pieces, the smallest proportion of voids.

If the aggregate is all of one material, the desired aggregation can be determined by weighing a given measure. That proportion which, while retaining the maximum amount of large pieces, weighs the most is the best.

If, on the other hand, the aggregate is composed of different materials, then that proportion which, in a given measure and under the same limitations as just given, will permit of the introduction into the filled measure of the least quantity of water is the best.

In making such tests, the larger the measure, the better; a round measure is better than a square box, and it should not contain less than two cubic feet. The material also ought to be shaken down into the measure.

For fireproof work, care should also be taken to avoid such aggregates as contain feldspar, and where the possibility of the concrete being subjected to a long continued red heat is sufficiently probable as to be worthy of precautions being taken to meet its effects, limestone also should be rejected from the aggregate.

To those who have studied the matter practically, it is evident that in the large majority of cases the prejudice against the use of the dust and finer particles created in crushing brick or stone is unfounded, and the practice of prohibiting these and substituting therefor ordinary sand is strongly to be condemned. Lieutenant Innes found that both limestone dust and ground burned clay gave stronger results than the purest sand, and tests and works carried out under my supervision thoroughly corroborate this.

The hardest stone does not necessarily make the best aggregate. For instance, finely crushed granite is for some purposes inferior to finely crushed limestone, although, as a rule, the granite is the harder of the two. One reason for this is not hard to seek. Owing to the brittle quality of granite, in crushing, it is not only broken into small pieces, but many of these pieces are so bruised or contused that upon a little pressure being exerted upon them, such for instance as can be applied by the finger or thumb, they will crumble. With limestone and many other softer rocks, by reason of their greater toughness and elasticity, this is not the case.

Again, some stones, as quartz and the like, have surfaces of such smoothness that the adhesion of the cement thereto is not so good as that between cement and other stone, such as basaltic lava, sandstones and the like, which, when fractured, present a rough surface. Such stones as these latter usually make first class aggregate. Broken stone, as a general thing, is a better aggregate than gravel. Sometimes a mixture of the two is preferable to either alone. Usually the use of one or the other has to be determined by the economic side of the question and the local supply. When from such causes gravel is selected, its quality can be greatly improved, at small cost, by running it through a crusher that will break the larger pieces as they pass.

The common practice of limiting the maximum size pieces so that they will pass through a three inch ring is, I think, open to question. In massive work stones much larger may advantageously be used, not, however, if the late fashionable practice of dry concrete be adhered to.

The experiments carried out by Mr. Elliot C. Clarke tend to show that the presence of a small amount of clay in the concrete is no detriment to its strength, even with as much as ten per cent. of the aggregates and cement combined.

In corroboration of this I would instance the Niagara gravel, which while it contains a marked quantity of clay, yet makes most excellent concrete.

Having determined the aggregate, the next important question is what is the proper proportion of cement to use for any given work.

With first-class materials, in round figures and, within the limits of proportions between the cement and the aggregates of from one to four, to one to fifteen, the crushing strength of concrete, when skillfully made, at a month old, may be taken as follows: Multiply the constant number 700 by the number representing the proportion of cement used and divide it by the number representing the amount of aggregate used, and it will give the crushing strength in tons per square foot; for instance, a concrete composed of 1 part of cement to 14 parts of aggregates should, when properly seasoned, have a crushing strength of $\frac{700 \times 1}{14} = 50$ tons; when three months old the strength will have increased some twenty-five per cent. and when twelve months old it will have increased some fifty per cent.

Under this rule a concrete composed of 1 of cement to 14 of aggregate would be about on a par with good brickwork when a month old and be about fifty per cent. stronger when twelve months old. This rule reduces the strength of the concrete too much as the proportion of aggregate is increased, but it is reasonably correct, and quite safe to act upon.

Section C. Iron.—The tensile strength of concrete is comparatively little, and by reason of the gradual though slight shrinkage that takes place in all concrete structures that age in dry situations, should not be relied upon in any important work.

For giving tensile strength to concrete, all modern workers of note now use iron in some form or other.

Angular iron bars, cold twisted, commend themselves in many ways, and on this continent they have been more largely used than any other form in concrete iron construction.

The advantages of this cold twisting are many; they may be summed up as follows:

1st. The tensile strength of the iron is largely increased, viz., from 20 to 50 per cent., dependent upon quality of iron used.

2d. Its elongation under strain is considerably lessened, a very important advantage in concrete iron construction.

3d. It forms a continuous key with the concrete, both longitudinally also athwart the bar. The effect of the twist is to grip the concrete in every direction, and in fireproof flooring and other work where light construction is desired, the importance of this universal key is very great, for it counteracts the tendency which a bar otherwise would have to split the concrete along its longitudinal line.

4th. The cost of twisting is nominal and the royalty for its use not prohibitory.

In placing these bars care should be exercised in putting them in the position where they will best exert their strength. They should be straight and laid directly in the line of strain. Any deviation from this rule should be such that the tendency to straighten, which invariably occurs upon the application of the strain, will do little or no damage, such a deviation for instance as laying a bar of a floor beam with a slight sag in the center. In such a case when the strain takes place, the tendency to straighten would have the effect of thrusting the center of the bar upward against the downward thrust of the load, and it would be harmless. If on the other hand the bar was laid crowning in the center upon the floor being loaded, the tendency of the bar to straighten would be in the same direction as that of the downward thrust of the floor load and the consequences would be detrimental, if not fatal, to the integrity of the structure.

Concrete is an excellent conservator of iron. Von Emperger states that he knows of a case where iron rods were found perfectly rust free after having been embedded in concrete below the water level for forty years. (T.A.V.C.E. Vol. 31, p. 447.) W. G. Triest, Jr., states that a wrench that had been buried in concrete twenty-two years had kept its black metallic surface. (T.A.V.C.E. Vol. 31, p. 467.)

Referring to some concrete foundations that I built about ten years ago, the president of Starr & Co. writes as follows under date of December 30, 1893: "Though this foundation is on tide land and submerged in salt water more than half way up, there is no rusting or deterioration to the iron. We had occasion to cut through one of the arches and found the iron as stated." A long time ago I embedded a dozen pieces of hoop iron in as many blocks of concrete, leaving one end of each piece of iron projecting from the surface. After years of exposure to sea air, all the exposed iron had rusted away, or so nearly as to leave but a few soft, jagged needles of rust that were readily removed by the hand. In all cases upon cutting into the blocks I found the iron almost as good as new, and from one to two inches from the surface it was invariably so.

Section D. Water.—The water for mixing should be clear, and by preference soft. If it cannot be obtained of ordinary purity, then due allowance should be made for the impurities by an additional quantity of cement.

Sufficient water should be used to bring the mass when thoroughly mixed into a stiff, sticky, tenacious, viscous condition. An error as to the amount of water that should be used in concrete some years ago crept into the professional practice, both of engineers and architects, and with surprising rapidity permeated and revolutionized it. I allude to the erroneous theory that only sufficient water should be used to slightly moisten the mass, and hardly enough to render it cohesive in its uncompacted state.

An error seldom takes the hold this did upon a skilled body of men without some apparent justification. The only justification that I have been able to find after considerable research is the fact that in making briquettes for testing purposes, the use of a minimum quantity of water gives the best results. From this one little isolated fact the generalization was made, that to produce the best results concrete should be mixed in like manner. The fatal flaw in this deduction lies here, viz., that a mixture of cement or of cement and sand, with water, differs radically in conditions when to either of these gravel is added, and differs yet more if broken stone is used.

If cement or cement and sand is mixed with a large proportion of water, it cannot be compacted by blows or such pressure as can usually be brought to bear, for the mixture would flow from under the tamper. In the latter case, however, where gravel or broken stone are used, with a larger proportion of water, the concrete can be compacted more intimately and closely than with the minimum quantity, and under all ordinary conditions makes a much better concrete. The only exception to this is where smooth, rounded pebbles only are used with the mortar of the concrete, but this exception does not apply to ordinary gravel and never applies where broken rock is an ingredient. I allude to this at some length, because the error, although on the wane, is still widespread.

3. Tools.—There is a great advantage and economy in mill mixing. Mills can now be obtained at a reasonable figure and should always be used on large works. By their use the cement is more fully utilized, the cost of labor lessened and the work is more uniform and satisfactory in character.

An objection is often made to mill-mixed concrete, viz., that the concrete is injured by overmixing. What is overmixing? A very rare distemper this. I have never once met with it, although I have been actively engaged in concrete construction for thirty-five years. It is never epidemic or fatal, but like vaccination, if present, it would prevent worse and more fatal ailments.

Mr. Spencer Newberry found that a mixture of one of cement to three of sand which, when worked for one minute with a trowel, developed a tensile strength of 87 pounds in seven days, developed a strength of 240 pounds in the same period after being worked with a trowel for five minutes—a remarkable result, surely, and well worthy of consideration.

Contrary to the almost universal opinion, Portland cement is improved by a delay between mixing and placing. I have experimented with several brands of Portland cement, and find that they were invariably improved in tensile strength by a delay of from one to four hours between mixing and placing.

In placing concrete it is preferable to have it of one uniform consistency throughout the mass. In cases, however, where it is required that the face of the work should be of a finer grade, both grades should be carried on simultaneously, the face grade being placed up against the sheeting or mould a little in advance of the backing by means of a trowel or other convenient tool. In more careful work thin strips of iron about six inches wide and of any lengths convenient may be set up on edge in the concrete parallel to and at any desirable distance from the face of the mould. The face concrete should then be inserted between the mould face and the iron while the backing is placed at the other side thereof. As each layer is put in, the iron is drawn up a few inches, so that when the concrete is tamped, the effect of the tamping is conveyed below the lower edge of the iron, and causes the two grades of concrete to become thoroughly united and monolithic.

The material should in ordinary cases be placed in thin layers, seldom greatly exceeding in depth the length of the largest aggregates used, and these layers should follow one another sufficiently quickly so that one layer does not become stiff or partially set before the next is upon it.

Flat tampers should not be used for massive work,

except in the first and last layers of the day's work; thin or edged tampers should be employed. Wherever practicable the concrete should be compacted by rolling in preference to tamping. It is cheaper and much more effective. I am not aware of its being done outside of my own practice, but it is certainly deserving of almost universal use. On large work steam rollers would be excellent.

It may be accepted as an axiom that concrete cannot be too thoroughly compacted, provided the action is not violent enough to bruise or crush the aggregate.

In massive or deep work, as it proceeds through the day, often the working surface becomes richer in mortar, when, and as often as this occurs, the mixture should be changed by adding thereto more of the larger aggregates, free from fine dust, sand or gravel, until this fault is remedied. If, on the contrary, at any time the surface becomes open for lack of mortar, it should be immediately remedied by putting into the next mixture a lesser quantity of the larger aggregates and not substituting anything in their place.

In a similar way the amount of water used in the mixings should be regulated, changing to more or less as the working surface appears too stiff or too watery. It should be firm under the tamper or roller and yet the mortar should be viscous and unctuous to the touch.

The quantity required to produce the condition varies greatly, dependent upon the character of the aggregates, whether but slightly or very porous, and upon the age and character of the cement and weather.

Great care should be observed in joining the work of one day to that of the next. The last layer should be thoroughly compacted and left with a slight excess of mortar. It should be finished with a level surface, which, at proper time, as soon as sufficiently stiff, should be patted or stippled with a steel float so as to produce a surface studded thickly with little conical knobs. This surface should be kept wet throughout the night, and in the morning immediately before the application of the first layer of fresh concrete it should be covered with a wash consisting of a mixture of equal measures of Portland cement and air slaked lime mixed with water to the consistency of thick cream. This covering should be put on in excess and brushed thoroughly back and forth upon the surface, so as to insure a close contact therewith, the excess being swept along just ahead of the fresh concrete until all the surface has been covered, when it should be removed.

When in place the concrete should be kept moist for as long a period of time as possible. When one bears in mind that the chemical action which causes the cement to harden can only take place in the presence of moisture, the importance of keeping the work wet is at once apparent.

In all concrete construction, excepting subway and other works where the concrete remains permanently moist, provision should be made for the slow but certain shrinkage that takes place in the concrete as it becomes thoroughly dehydrated. The vertical shrinkage will take care of itself, as the weight of the building is in harmony with its movement. The horizontal shrinkage, however, is resisted by the inertia of the structure and the friction of its foundation. There are several ways to direct such shrinkage; that which I have found most feasible is to partially divide the wall at certain intervals, preferably over the windows, where there are several in line, and to insert across the division a weathering strip of copper or lead.

Where the appearance of a straight division line on the face of the building would be objectionable, for instance, on a wall blocked off into ashler face, I build this division straight and cause it to coincide with the line of the V recesses of the ashler, marking in every other course, and I block out in the intermediate courses recesses opposite to the division line and subsequently fill these recesses with concrete ashlers made and seasoned beforehand. By adopting the pattern of alternate long and short ashlers in every other course with long ashlers only in the immediate course meeting at the center line of the short ashlers above and below them, there separate concrete ashlers may be made small and the additional cost of their manufacture will be but trifling.

Apart from the questions of appearance, some such division of the surface of a concrete wall is advisable, for the twofold reason; some defining line is needed at the juncture of each day's work at least, and by dividing up the surface by deep recesses into small sections, surface cracking is largely avoided.

In reference to this shrinkage of concrete, lest I should have unnecessarily alarmed you, I will state that in a building the walls of which were 170 feet long, and divided thus, it was nearly two years before any apparent shrinkage took place, and now it can hardly be observed by a minute examination of the division joints. No outsider, even though a careful observer, would be likely to perceive any effects of this slight shrinkage when thus directed.

In situations where it is not possible to make shrinkage joints by a liberal use of twisted iron, shrinkage cracks can often be prevented.

The Resistance of Portland Cement Concrete to the Destroying Action of Fire.—By a misunderstanding, due to a windy interference (Mr. Stone tells me one of my letters was blown out of his office window), I find I am expected to speak on the protection concrete affords iron in case of fire.

There seems to be not so much data on this subject as one would desire. What little there is, however, seems to be in favor of concrete as a fire resistant.

It is generally understood that the artificial stone made with Portland cement concrete withstood the Chicago fire well. Some years ago the blacksmith's shop at the Benecia Arsenal, California, was burned out, leaving the outer walls standing. This was a brick building, with granite door sills, freestone belt courses, with window caps and cornice of Portland cement concrete. I examined the ruin carefully. The granite was spoiled badly and broken into several pieces, the freestone was badly broken and injured, the brick work was burnt out in the joints in many places, rendering the walls unsuitable, many of the bricks also being spoiled, while the concrete window heads, which had probably to bear the brunt of the fire, on the outside, were but little injured; the surfaces had softened a trifle and were badly discolored, but they remained whole and strong.

Concrete bricks, made of well burnt clinkers and lime (by a process which converts the lime into silicate of lime and thereby makes it resemble a Portland cement in character), withstand the action of a hot fire and the subsequent sudden cooling by water better than any burnt brick, either common pressed or fire brick, that I could obtain in San Francisco, and I presume the same relative result would be obtained from most of the bricks of the several States.

I have repeatedly made the tests so severe that every burnt brick in the dozen or so tested at a time broke into two or more pieces, while under the same test the concrete bricks, beyond discoloring slightly, showed no change.

The Thermic Expansion of Portland Cement.—Bonnicean is quoted as giving the expansion of Portland cement at 0·00000143 for 1° Celsius, and iron is given at 0·00000145, which is practically the same.

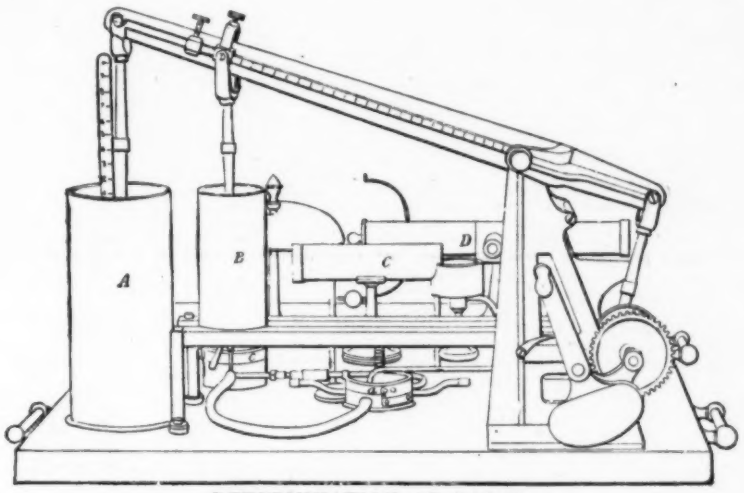
Hyatt corroborates this in some careful experiments he made with loaded floors submitted to fire, in which the concrete iron construction bore a red heat for several hours and a subsequent sudden cooling without injury.

Throughout Europe, I believe, hollow tile construction is almost unknown. Concrete floors are commonly used in fireproof buildings. The result of tests undertaken in Germany under government supervision, to ascertain the relative value of the ordinary building material, including brick work, places concrete at the head of the list as the best fire resistant.

If due regard is paid to the aggregate used, I think it will be found that Portland cement concrete is an excellent fire resistant.

DETERMINATION OF COMBUSTIBLE GASES.

THIS apparatus, invented by Thomas Shaw, of Philadelphia, chiefly consists of two pumps, A and B (see figure); the larger pump, A, constantly pumps the same volume, being fixed in position, as also is the length of the beam working the pump rod; the smaller pump, B, on the other hand, is movable and the pump rod can be so arranged by means of a scale along the beam as to deliver any required fraction of the maximum. A pumps air, or a mixture of air and combustible gas, while B pumps combustible gas only, viz., hydrogen, methane, illuminating gas, etc. Any



DETERMINATION OF GASES.

required mixture of air and combustible gas can accordingly be made as required by pumping air by means of A, and the requisite proportion of combustible gas by means of B. In order to use the arrangement the sample of air or other mixture of gases containing inflammable gas (contained in an India rubber bag) is first of all tested by pumping, together with air, into the testing cylinder, C, and applying a light; if the explosion produced is violent, a smaller quantity of the gas to be tested is employed relatively to the air, the mixture being pumped into the explosion cylinder, D, and fired by a flame; if the explosion then produced is not too weak, the concussion projects a striker on to a bell, so as to ring a signal audibly. A series of trials is then made with gradually decreasing quantities of combustible gas until the limit is reached, when the violence of the explosion is not sufficient to ring the bell. For samples containing only small quantities of combustible gas, a series of observations is made with coal gas (or hydrogen, etc.) and air, until a corresponding limit is arrived at, e. g., 8·0 per cent. of combustible gas; another series is then made with the air containing combustible gas to be tested and the same coal gas (or hydrogen, etc.); if in this case the limit found is 5·3 per cent. of coal gas, etc., it results that the quantity of combustible gas in the air tested is practically equivalent to 8·0—5·3 =2·7 per cent. of the coal gas, etc., used.

EXPERIMENTS IN THE LIQUEFACTION OF HYDROGEN.*

THE strenuous efforts now being made by physicists to approach the zero of temperature are in some ways analogous to the numerous attempts that have been made, or are now being made, to reach the North Pole. It must be confessed, however, that the geographical quest has the enormous practical advantage of appealing forcibly to the popular imagination, while the interest and importance of the physical inquiry are appreciated by a comparatively small section of the community. In both cases success may be said to depend upon equipment, persistency, and the selection of the right road. In neither case can the anticipated results be considered as likely to be of immediate practical value.

The North Pole will not be the signal post of a trade route, and the condensers of our engines are never likely to reach the zero of temperature. If the latter could be obtained, however, the results would be highly practical, because we should then completely transform heat into mechanical power, instead of getting only 10 per cent. converted by our present means of working.

The solution of the problem of the North Pole will add greatly to our knowledge of physiography, and the approach to the zero of temperature will open fields of investigation where matter and energy can be examined under new conditions. The parallel between getting to the Pole and reaching the zero of temperature breaks down, however, when examined a little more carefully. There seems to be no reason why man should not attain the 90th parallel of latitude as well as the 75th; but in the case of temperature there are strong grounds for the belief that the zero can never be reached. The temperature of celestial space can only be approached in the laboratory, yet the nearer we get to it the more important physical problems become.

Up to the present liquid air or nitrogen is the agent that has been most successfully used in such investigations. When liquid nitrogen is evaporated in vacuo, a temperature of about 210° C. below the melting point of ice can be just reached, but the practical working limit in such experiments is about minus 200° C. This temperature is still 74° from the zero, and the question now is, Can we diminish the distance? The zero may be defined as that point of temperature at which gas particles would give no pressure and have no volume. The temperature at which this would take place is 274° below the freezing point of water, and this result is confirmed by thermo-dynamical considerations where temperature is defined apart from the properties of any particular kind of matter. The only avenue of approach that is left seems to be the liquefaction of hydrogen, which is the sole remaining gas that has not been liquefied. It is true all the text books state the reverse, on the ground that it has been proved that compressed hydrogen when expanded can yield a mist. Such statements have added nothing to the advance of knowledge in this department. On the contrary, they have done harm by making the ignorant believe that the most permanently gaseous element has been vanquished. The attainment of any such result is, indeed, a problem surrounded by almost insurmountable difficulties.

The possibility of making a gas pass into the liquid state depends upon our being able to get below the point of temperature known as the critical point. Unless this point is reached, no amount of pressure can force the gas into the liquid condition. Now, hydrogen has a critical point of about minus 240°, and the question is, How can we attain such a temperature, seeing that liquid air or nitrogen only enables a temperature of minus 200° to be reached? How can these 40° or 50°, as the case may be, be bridged over? This can only be done by constructing a new substance, having a critical point of minus 200°, or some 50° lower than nitrogen, which is the most volatile known liquid. Such a body can be made by liquefying a gas composed of hydrogen mixed with 10 per cent. of nitrogen. This is the direction in which Prof. Dewar has been lately pressing forward his investigations, and the new results give hopes of further advance. The really serious question is the extremely small proportion of the liquefied material that can be collected in open vessels. In order to understand this it is necessary to keep in mind that, when a substance is near its critical point, it has a very small latent heat of evaporation, but a very high specific heat. It follows, therefore, that, in order to get the liquid cooled by its own evaporation from near its critical temperature to its boiling point, a very large proportion of the liquid produced under high compression in the refrigerating apparatus has to be sacrificed. Thus, for instance, one pint of liquid air collected in one of the well known open vacuum vessels necessitates the liquefaction of some three pints of liquid in the apparatus. In other words, two-thirds of the original amount of liquid produced has to evaporate in order to procure the remaining third at its own boiling point. The proportion of the resulting liquid in each case depends, as above stated, on the latent heat of evaporation, and the specific heat of the particular liquid—if we neglect for the present the serious question of cooling the vessels—and the loss of heat by radiation and conduction. All our present experience confirms the view that the latent heat of evaporation is proportional to the absolute critical temperatures, or what is about the same, to the absolute boiling points. As the absolute critical point of hydrogen is about 40°, while that of nitrogen is 128°, it is clear that the latent heat of liquid hydrogen would only be one-third that

* From the London Times, September 1, 1894.

of liquid nitrogen or air. Further, analogy leads us to the conclusion that the specific heat of liquid hydrogen is very much greater than that of liquid nitrogen or air. The combined result must therefore be that, if practically only 30 per cent., as above described, of liquid nitrogen or air can be collected, a very much smaller amount of hydrogen, say from 1 to 5 per cent., is all we can anticipate as the yield by similar methods of manipulation. Assuming that we had such a liquid, its use as a cooling agent would indeed be very expensive, since its cost may be taken as at least twenty times the cost of liquid air. One thing, however, can be proved by the use of the gaseous mixture of hydrogen and nitrogen, viz., that by subjecting it to high compression at a temperature of minus 200°, and expanding the resulting liquid into air, a much lower temperature than anything that has been recorded up to the present time can be reached. This is proved by the fact that such a mixed gas gives, under these conditions, a paste or jelly of solid nitrogen, evidently giving off hydrogen, because the gas coming off burns fiercely. Even when hydrogen containing only some 2 to 5 per cent. of air is similarly treated, the result is a white solid material (solid air) along with a clear liquid of low density which is so exceedingly volatile that no known device for collecting it has been successful. To attain such a result it is necessary to liquefy and expand more than one pound weight (or about seven cubic yards) of hydrogen gas. Knowing the difficulties, from having to deal in the liquid state with the accumulated small impurities in such large amounts of gas, Prof. Dewar will not declare that he has had pure liquid hydrogen in one of his vacuum vessels, although what this liquid can be except hydrogen it is impossible to say.

The future progress of these costly and difficult experiments must depend very much upon questions of outlay, and it is to be hoped that the public will not assume that the endowment so handsomely given to the Royal Institution by Mr. Ludwig Mond for the maintenance of a public laboratory of research, to be called the Davy-Faraday Laboratory, can be used for the prosecution of such investigations.

SYMPATHETIC EXPLOSIONS.

By C. A. MITCHELL, B.A. Oxon.

IN an explosion we have the sudden evolution of large quantities of gas which meet with external resistance. Thus, in the case of dynamite, the substance is suddenly decomposed into gases, which meet with the resistance offered by the surface of the earth on the one side and with that opposed by the weight of the atmosphere on the other.

Explosive agents are roughly classified as "high" and "low" explosives, the former term being usually applied to those exploded by detonators and used as destructive agents rather than for the propulsion of projectiles. Nitroglycerine and gunpowder may be taken as representatives of the two classes.

Substances liable to explosion are, as it were, in a state of unstable equilibrium, and often a slight cause is sufficient to so disturb that equilibrium that a fresh arrangement of the particles takes place—in other words, an explosion. A somewhat analogous instance of instability is to be noticed in the case of water cooled slowly below its freezing point without solidifying, as occasionally happens in bedroom jugs. When the jug is lifted the movement destroys the equilibrium and the water suddenly becomes ice. Prince Rupert's drops illustrate the same phenomenon. These are small pear-shaped globules prepared by allowing molten glass to fall from a short distance into cold water, which causes the exterior to cool more rapidly than the interior, and the mass is left in such a state of tension that, if the extreme tip of the drop be broken off with pliers, the whole flies to powder.

Explosive bodies differ very considerably in stability. The so-called iodide of nitrogen, a black powder formed by digesting iodine in a solution of ammonia, explodes when dry with the slightest touch. Nitroglycerine is more stable and requires the blow of a hammer for its explosion. This substance is prepared by allowing strong nitric and sulphuric acids to act upon glycerine, care being taken to keep the temperature low. It is an oily liquid and is very poisonous. As an explosive it is uncertain, and has been the cause of many accidents. When mixed, however, with an inert substance, such as sawdust, it is much more stable. This is the principle made use of in the manufacture of dynamite, which consists of nitroglycerine absorbed by a porous siliceous earth called kieselguhr.

Dynamite is very stable under ordinary conditions, as was well shown in the experiments carried out in the Lauenburg Fabrik in 1876.* A barrel containing 540 kilogrammes† was dropped a distance of 20 feet on to a paved road, and in a second experiment a weight of 10 kilogrammes was dropped on to a dynamite cartridge. In neither instance was there any explosion. The dynamite used burned quietly when thrown on a fire, but exploded powerfully even on an open surface when a detonating cartridge was exploded in contact with it. We have thus the curious phenomenon of a substance which burns quietly and withstands a heavy blow, but which disintegrates readily when another less stable body is exploded beside it. This is explained by the theory of an explosive wave which is communicated from the one explosive to the other. Where an explosive burns quietly there is much slower decomposition, and the particles first taking fire radiate their heat too quickly for the entire mass to be simultaneously raised to the temperature of explosion. If the heat cannot be dissipated sufficiently fast, as in the case of confined gun cotton, an explosion follows just as when a detonator is used. Thus the unstable equilibrium may be disturbed either by heat or by communication of a mechanical vibration. This latter method of sympathetic explosion, as it has been termed, is now very generally used to effect explosion of charges of dynamite and gun cotton.

That the deflagration of one substance can produce a sympathetic explosion at a distance has been illustrated by many accidents. The explosion of a quantity of nitroglycerine in one shed has often caused the explosion of other materials some distance away. A remarkable instance occurred in 1888, in a factory at Wandsworth, where the caps for toy pistols were made. It was believed that the explosion was owing to one of these amorces, containing more than the regulation amount of composition, having been cut with scissors, and thus causing all the rest to explode. The shed was wrecked, and three girls lost their lives. A similar case happened in France, where a child was killed by cutting open a cap, which caused two large packets to explode.

When an explosion is communicated from one cartridge to another, there is a gradually weakening effect. This was proved experimentally in 1872, by Captain Muntz, at Versailles. The explosion of the first charge excavated a funnel-shaped hole in the ground measuring 0·9 meter* in diameter. The shock caused a second similar cartridge placed at some distance to explode. But in this case the diameter of the hole excavated was only 0·66 meter.

Captain Colville found that there was a definite relation between the weight of the charge used and the distance between the cartridges. A charge weighing one kilogramme, and containing 75 per cent. of dynamite, communicated its explosion on hard ground 0·3 meter. Where D represents the distance in meters, and C the weight of the charge in kilogrammes, he showed that under these conditions D = 3 C. When the cartridges were laid on a rail, the distance to which the explosion could be communicated was increased, and D = 7 C. On the other hand, on soft or plowed earth, the distances were much less.

To explain this property of explosives, Sir Frederick Abel advanced the attractive theory of a sympathetic rhythmic vibration between the substance detonating and that detonated, analogous to the synchronous vibrations set up by sound waves. A certain note of a piano will often cause a glass to jingle, and if the glass be made to emit its note, it will be found to be the same as the note of the piano—that is, each vibrates at the same rate. Sir Frederick Abel thus expresses his theory: "Vibrations produced by particular explosions, if synchronous with those which would result from the explosion of a neighboring substance, will, by their tendency to develop those vibrations, either determine the explosion of that substance or at any rate greatly aid the disturbing effect of mechanical force suddenly applied."

Facts in support of this are that sometimes a feeble detonation will determine an explosion when a more violent one will not. Thus iodide of nitrogen will not cause compressed gun cotton to explode, nor does nitroglycerine cause the explosion of gun cotton in sheets on which is placed the case of nitroglycerine.

The interesting experiments of Champion and Pellet† tend, perhaps, to confirm this.

1. A very small quantity of iodide of nitrogen, detonated at one end of a long narrow tube, caused the explosion of a similar quantity of the same substance placed at the other end of the tube at a distance of seven meters. That the transmitted concussion was slight was shown by the insertion of a light pith ball in the middle of the tube.

2. Damp iodide of nitrogen was fixed to the strings of a bass viol. When it was dry the strings of a similar instrument were made to vibrate at a distance. A detonation occurred only when a note giving sixty vibrations per second was sounded. The G cord caused an explosion, while the E cord did not. The vibrations produced by metal plates acted in the same manner as strings.

From these results the observers came to the conclusion that explosion was due to vibratory motion independent of heat and shock.

This theory has not met with general acceptance. Eissler‡ is strongly opposed to it. He urges that all the experiments of Champion and Pellet may be explained by taking into account the vibrations of the supports and the resulting friction. Moreover, the characteristic feature of a given note has never been established, but only the fact that below a certain rate of vibration the explosive effect ceases. He explains the facts by the supposition of two orders of waves, one explosive and the other purely mechanical.

In substantial agreement with him, Berthelot§ also objects to the theory of sympathetic vibrations. He proves that the chemical stability of matter is unaltered by merely sonorous vibrations, even when the substances experimented on are as unstable as ozone, which is so readily changed into oxygen. Therefore, according to him, sonorous waves cannot be the real agents in chemical decomposition and explosion. His explanation is that "explosive matter detonates, not because it transmits the vibratory energy by vibrating in unison, but, on the contrary, because it stops it and appropriates the energy." With reference to Abel's experiments, he argues that if gun cotton can explode nitroglycerine, why cannot nitroglycerine explode gun cotton, assuming that the two compounds vibrate in sympathy; whereas this transformation of energy into work may be readily explained by a difference in constitution.

The same chemist made a large number of experiments to determine the velocity of the explosive wave in the case of different explosives.‖ Long, narrow tubes, made of lead, tin, or Britannia metal were used, and the rate of propagation of disturbance through the tube measured. He found this to depend on: (1) The diameter of the tube; (2) the density of the explosive; (3) the resistance of the material of the tube. The explosive wave from compressed gun cotton had a mean velocity of 5,200 meters per second in lead tubes, and of 6,000 meters per second in tin tubes. Liquid nitroglycerine gave results varying from 1,078 to 1,386 meters per second; while dynamite had a mean rate of 2,543 meters per second. It was found a matter of great difficulty to detonate the nitroglycerine in such narrow tubes. A curious feature was, that whether the tubes were curved or straight, the results obtained were substantially the same.—Knowledge.

* Ber. Deut. Chem. Ges., IX., 1802.
† A kilogramme = 2·2 lb.

* A meter = 39·3 inches.
† Comptes Rendus, LXXV.
‡ Modern High Explosives.
§ Les Matieres Explosives.
‖ Comptes Rendus, 100, 314—320.

APPARATUS FOR WEIGHING OUT LIQUIDS.

THE weighing out of liquids which readily volatilize, of fats and oils, of fuming acids, etc., is a lengthy and inconvenient operation. The process is, however, much simplified by the use of the pipette shown in the figure. The exhaustion tube terminates in a capillary, which is bent within the bulb of the pipette toward the upper portions of its walls; the opposite side of the bulb is flattened in order that the pipette can be placed on the pan of the balance; the mouthpiece may be drawn out to a capillary, and the same applies to the discharge tube. A sufficient quantity of the liquid to be weighed is sucked up into the bulb so that the end of the capillary within the bulb projects beyond the surface of the liquid when the instrument is laid down on the flattened portion. After wiping the end of the tube, the pipette and its contents are weighed; the necessary quantity of liquid is then run out, and the weight redetermined. For weighing solid fats the instrument may be warmed; the error introduced by weighing a slightly warm liquid in a small pipette being for practical purposes quite negligible.—H. Schweitzer and E. Lungwitz, Chem. Zeit.

Fig. 1.

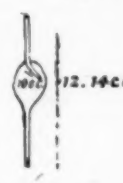


Fig. 2.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.
Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. AGRICULTURAL CHEMISTRY.—Influence of Nutriment upon the Length of the Roots of Plants.—A curious and direct experiment on the action of fertilizers on plants.—1 illustration..... 15723
II. ANTHROPOLOGY.—Aborigines of the West Indies.—By FREDERICK A. OBER.—Abstract of a most interesting paper on the Indians of the West Indies.—The first human beings found on the Western Hemisphere by Columbus..... 15719
III. ASTRONOMY.—Mars.—The Polar Snows.—By PERCIVAL LOWELL.—A popular article on recent observations of Mars.—Its snow caps and curious markings..... 15724
IV. BIOGRAPHY.—Li Hung Chang.—Note on the life of the Chinese statesman, with portrait and view of Che-Foo, Corea.—2 illustrations..... 15719
V. CHEMISTRY.—Apparatus for Weighing Out Liquids.—A pipette for laboratory use in weighing small quantities of volatile and other liquids.—2 illustrations..... 15734
Determination of Combustible Gases.—An apparatus for determining the proportions of air and gas required to produce violent explosions.—1 illustration..... 15733
Sympathetic Explosions.—By C. A. MITCHELL.—Experiments on the laws of explosion and deductions therefrom..... 15734
VI. CIVIL ENGINEERING.—A Cheap Planimeter.—A curious example of a planimeter of extreme cheapness and reasonable accuracy.—1 illustration..... 15731
Concrete Construction.—Its Practical Application.—By ERNEST L. RANSOME.—Monolithic construction by use of cement concrete, with full details..... 15731
Engineering Facts.—A very practical paper, treating of the problems of engineering life and errors of engineers..... 15727
The New Dam for the Chemnitz Water Works.—A new dam recently erected in Saxony.—An interesting example of German practice..... 15727
VII. DRAWING.—Drawing Office Rules.—A. W. ROBINSON.—A paper read before the American Society of Mechanical Engineers, giving rules for mechanical draughtsmen..... 15730
VIII. ENTOMOLOGY.—Insect Secretions.—By E. A. BUTLER.—A curious class of insects producing secretions of use to mankind.—2 illustrations..... 15722
IX. FINE ART.—The Work of Sculptors.—How the design of an artist is carried out by the sculptor proper.—3 illustrations..... 15730
X. FORESTRY.—Pterocarya Caucasica.—Note of a recent forestry conference in England.—1 illustration..... 15723
XI. GEOLOGY.—The Sydney Coal Field of Cape Breton, Nova Scotia.—By HUGH FLETCHER.—A description of the famous province coal beds, now worked for two hundred years..... 15724
XII. MINING ENGINEERING.—Answers to Questions asked Candidates for Mine Foremen's Certificates.—Questions and answers in examinations held last January in the Pennsylvania coal region. 4 illustrations..... 15728
XIII. NAVAL ENGINEERING.—Improved Hydraulic Capstans.—By ARTHUR RIGG.—A capstan worked by a hydraulic engine, with details of its construction.—1 illustration..... 15726
XIV. PHOTOGRAPHY.—A Double Refracting Finder.—A finder of a high degree of luminosity, that can be used in direct sunlight.—1 illustration..... 15729
XV. PHYSICS.—Experiments in the Liquefaction of Hydrogen.—A popular and exceedingly clear article on the last experiments in the liquefaction of gases..... 15733
XVI. TRAVEL AND EXPLORATIONS.—Kilauea Volcano Seen Anew.—By Rev. SERENO E. BISHOP.—A graphic account of the descent to the crater of the famous volcano of the Sandwich Islands..... 15725

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *nearly fifty years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them; directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases. Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.